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(54) **OBJECT IDENTIFICATION USING SURFACE OPTICAL ARTIFACTS**

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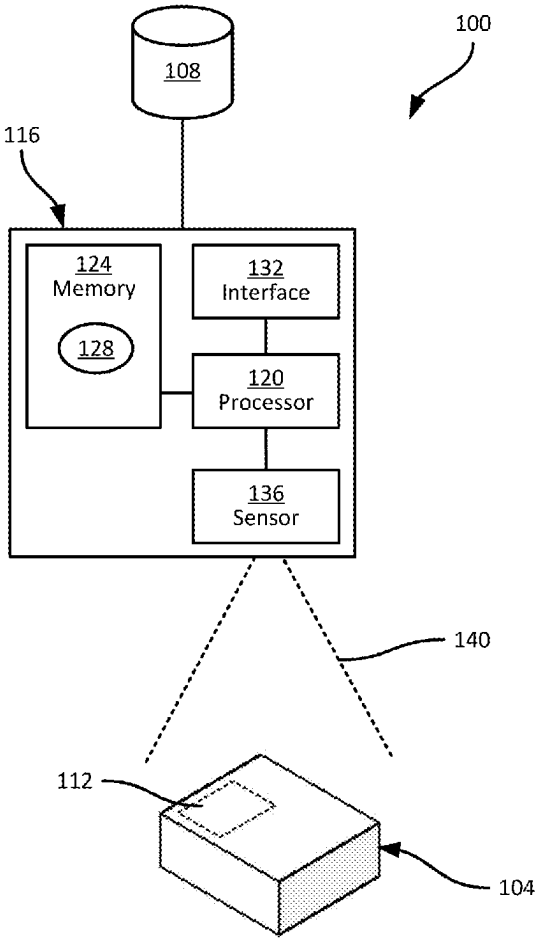
(57) **ABSTRACT**

A method of object identification includes: capturing an image of an object having a material presenting surface artifacts; detecting a boundary within the captured image; selecting a portion of the image depicting the surface material within the boundary; based on the selected portion of the image, determining attributes of the surface artifacts; generating, based on the determined attributes of the surface artifacts, a physical identifier corresponding to the object; and storing the generated physical identifier.



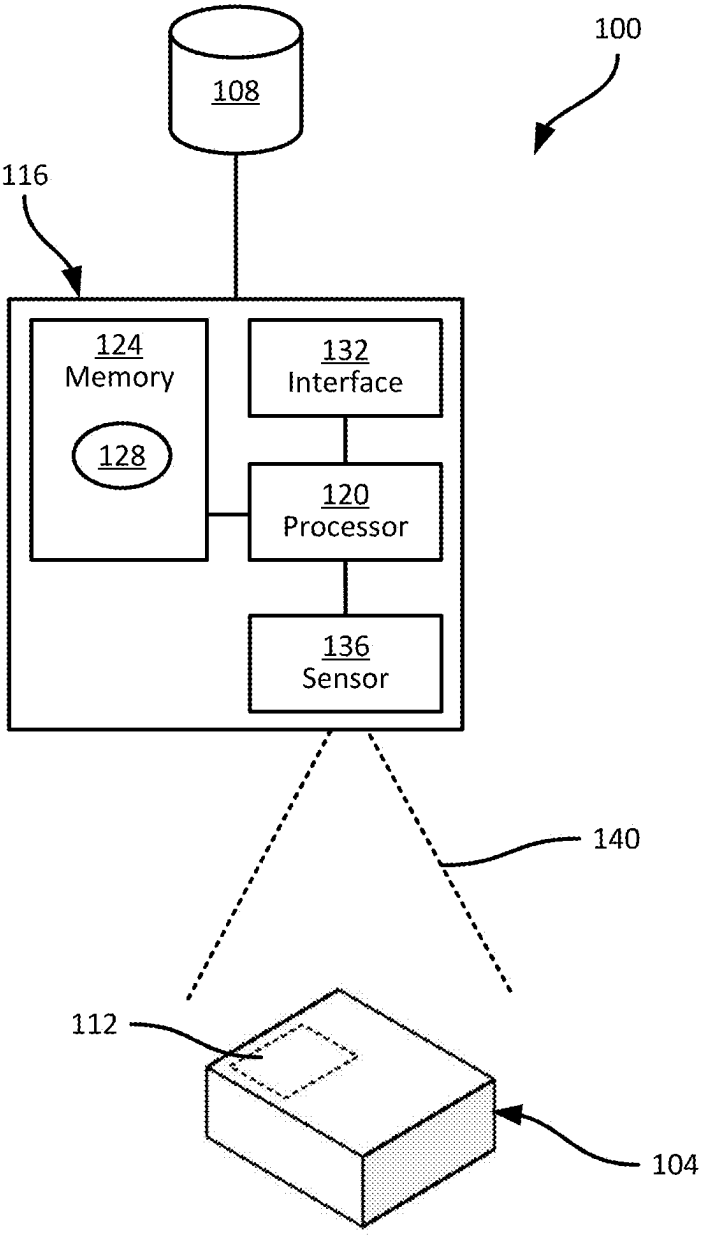

100
108
116
124
Memory
128
132
Interface
120
Processor
136
Sensor
140
112
104

FIG. 1

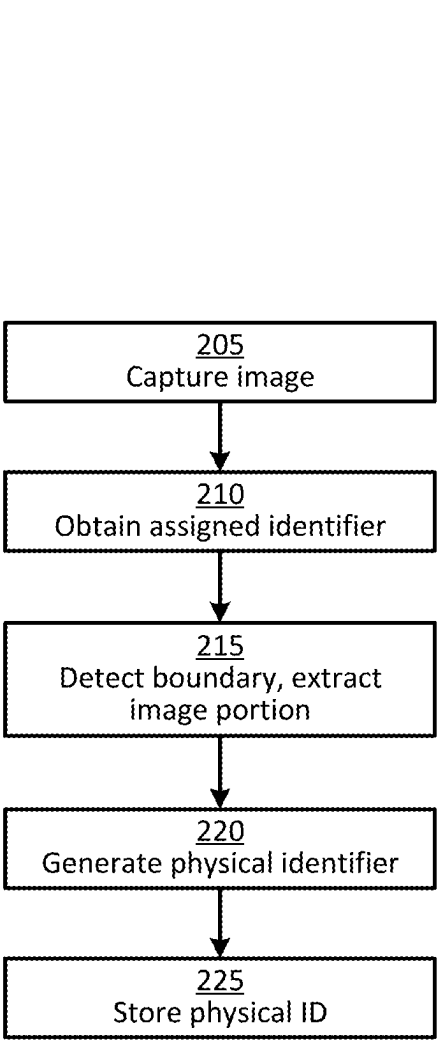

200
205
Capture image
210
Obtain assigned identifier
215
Detect boundary, extract image portion
220
Generate physical identifier
225
Store physical ID

FIG. 2

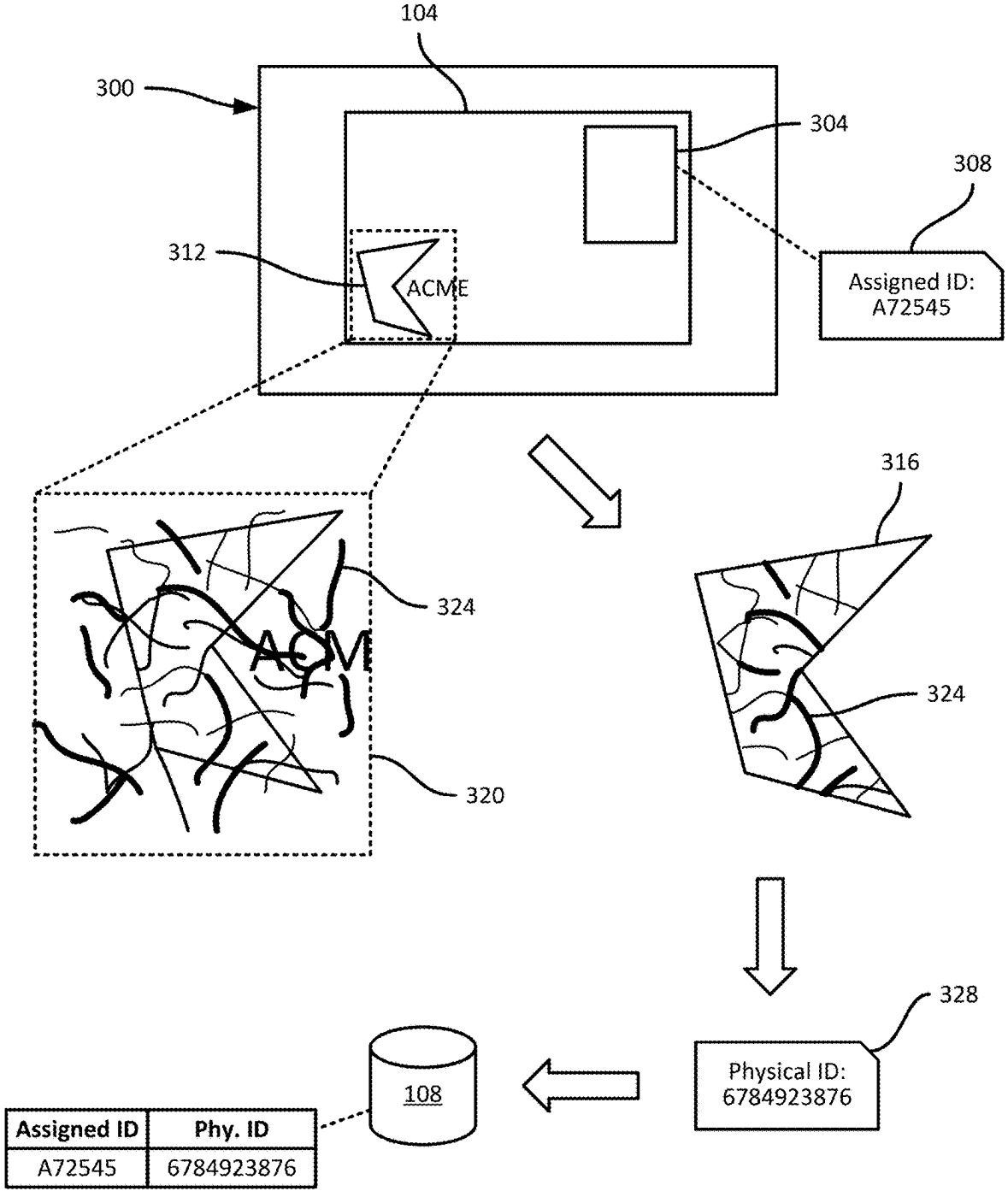

104
300
304
308
312
ACME
Assigned ID:
A72545
316
324
ACME
324
320
328
Physical ID:
6784923876
108
Assigned ID
Phy. ID
A72545
6784923876

FIG. 3

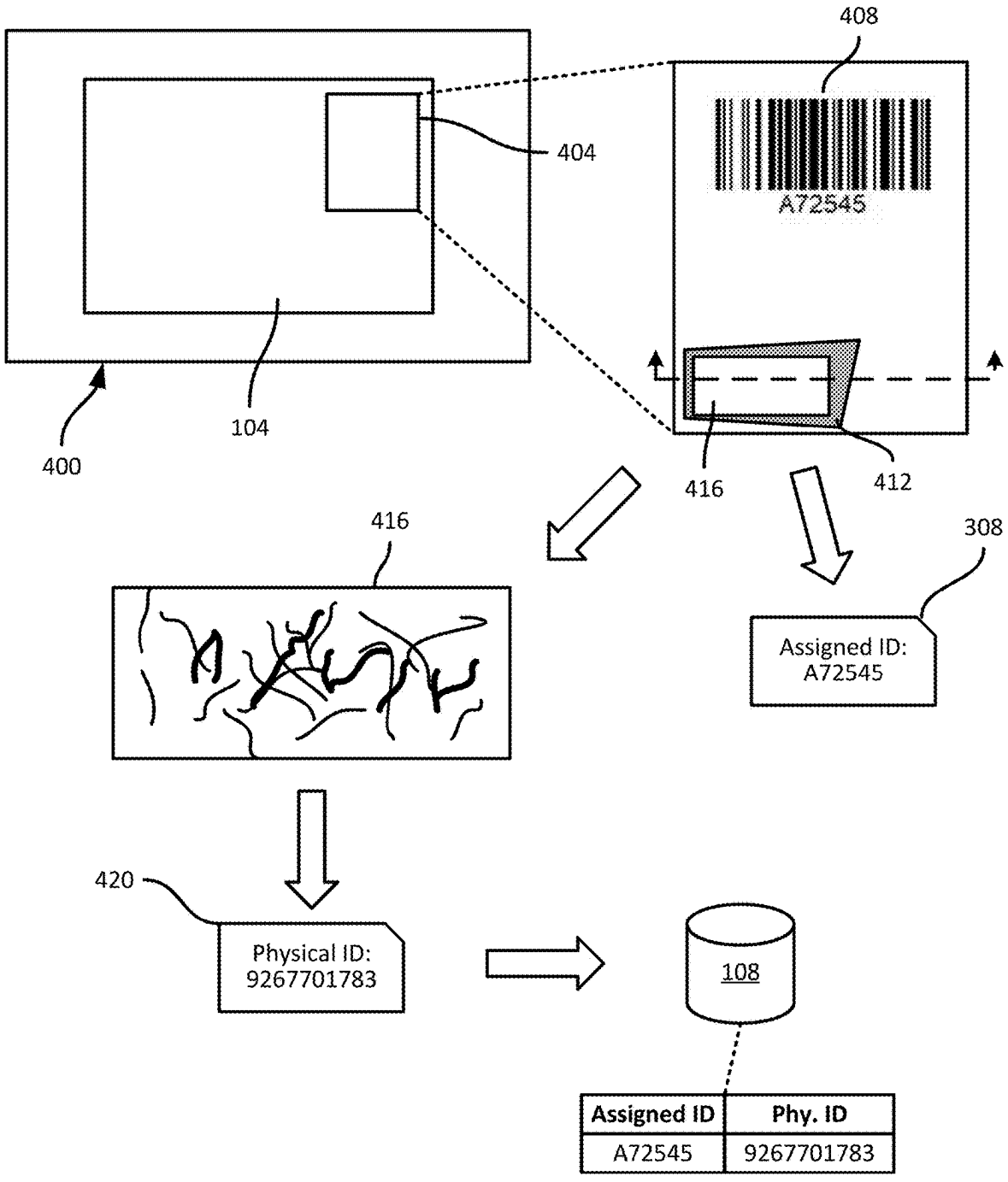

408
404
A72545
400
104
416
412
416
308
Assigned ID:
A72545
420
Physical ID:
9267701783
108
Assigned ID
Phy. ID
A72545
9267701783

FIG. 4

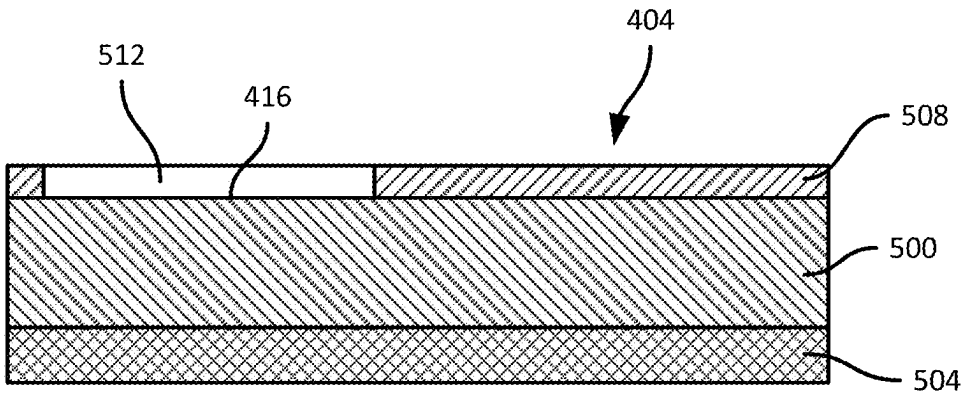


FIG. 5

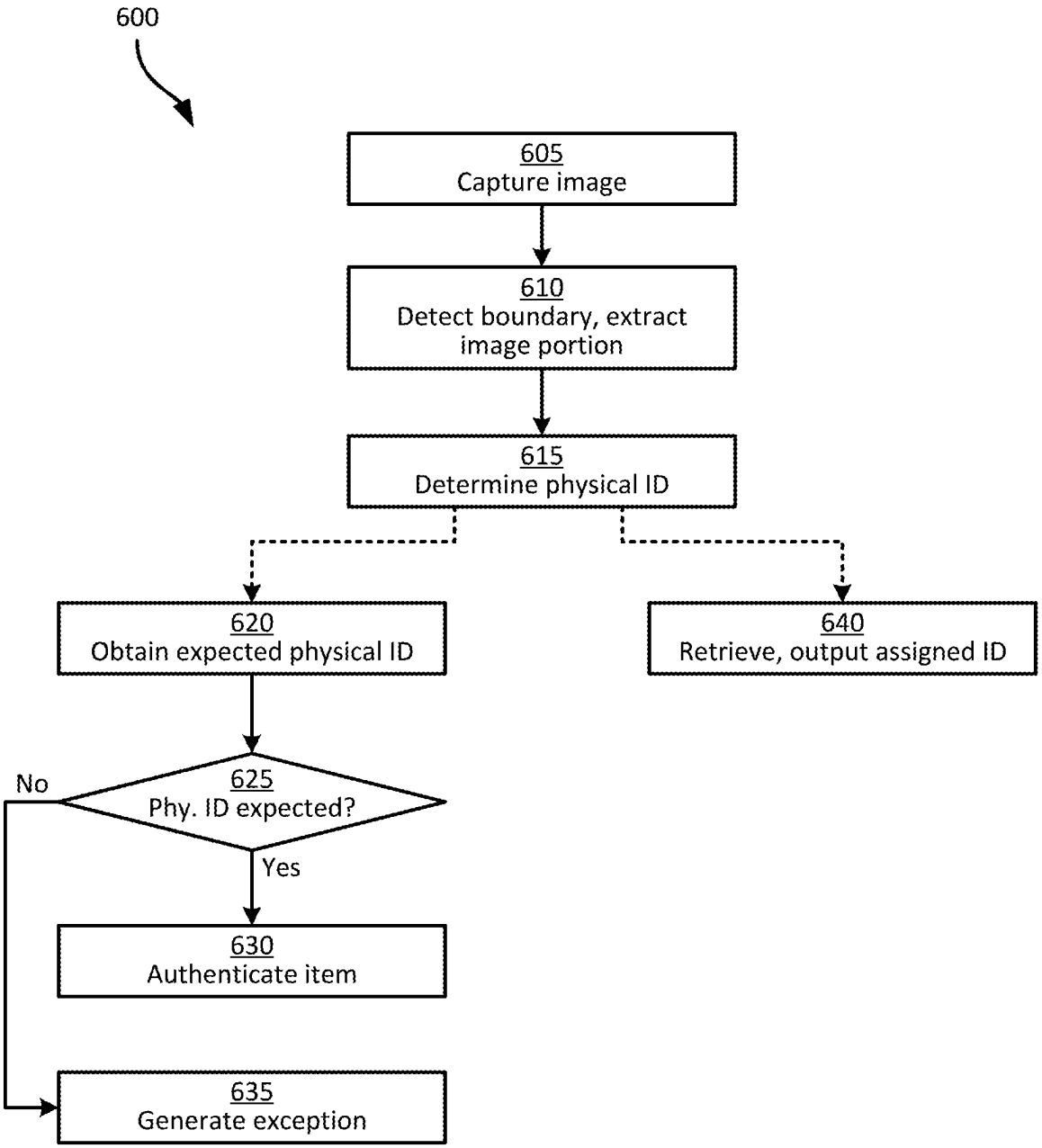

600
605
Capture image
610
Detect boundary, extract image portion
615
Determine physical ID
620
Obtain expected physical ID
640
Retrieve, output assigned ID
625
Phy. ID expected?
No
Yes
630
Authenticate item
635
Generate exception

FIG. 6

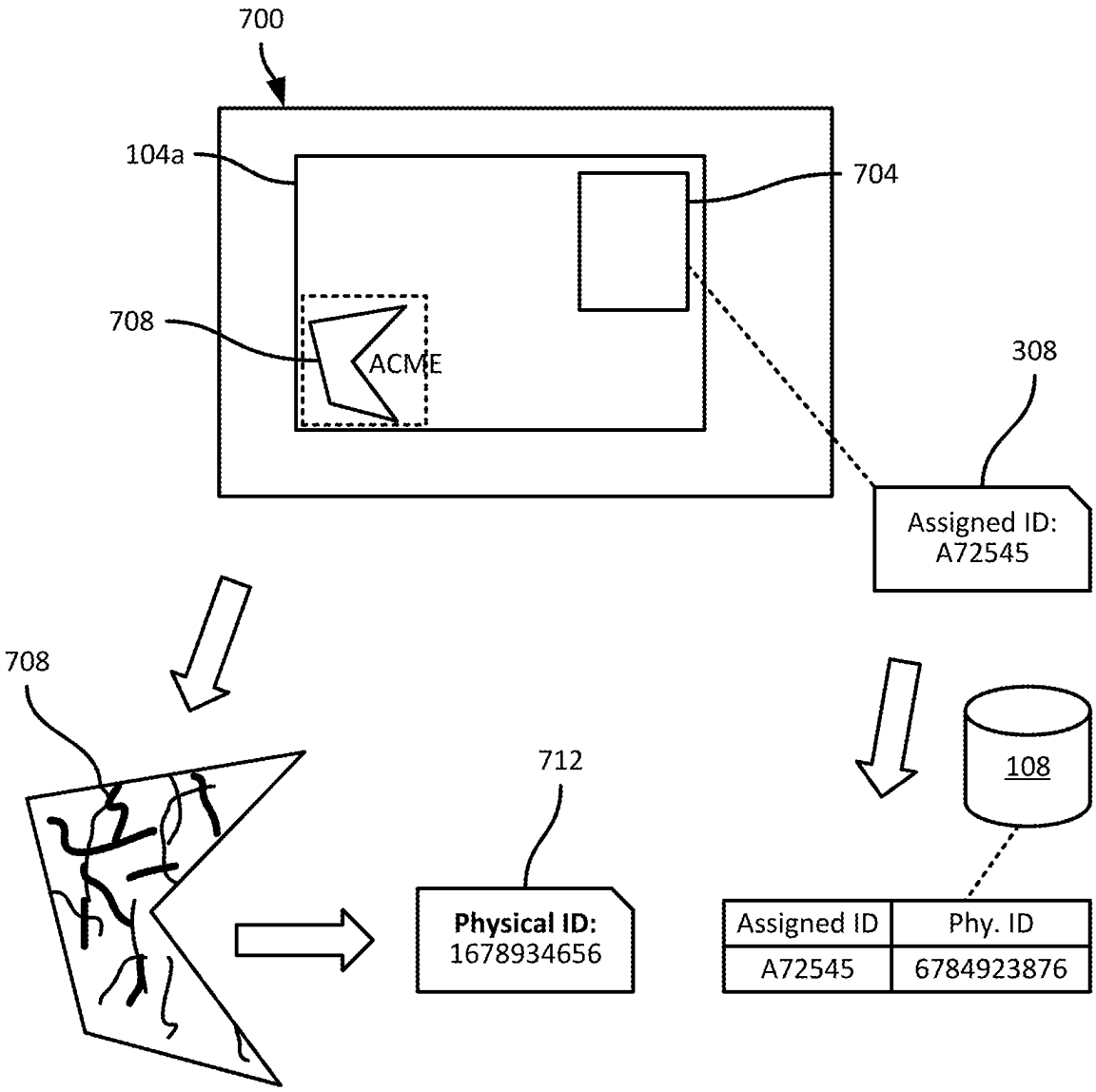

700
104a
704
708
ACME
308
Assigned ID:
A72545
708
712
108
Physical ID:
1678934656
Assigned ID
Phy. ID
A72545
6784923876

FIG. 7

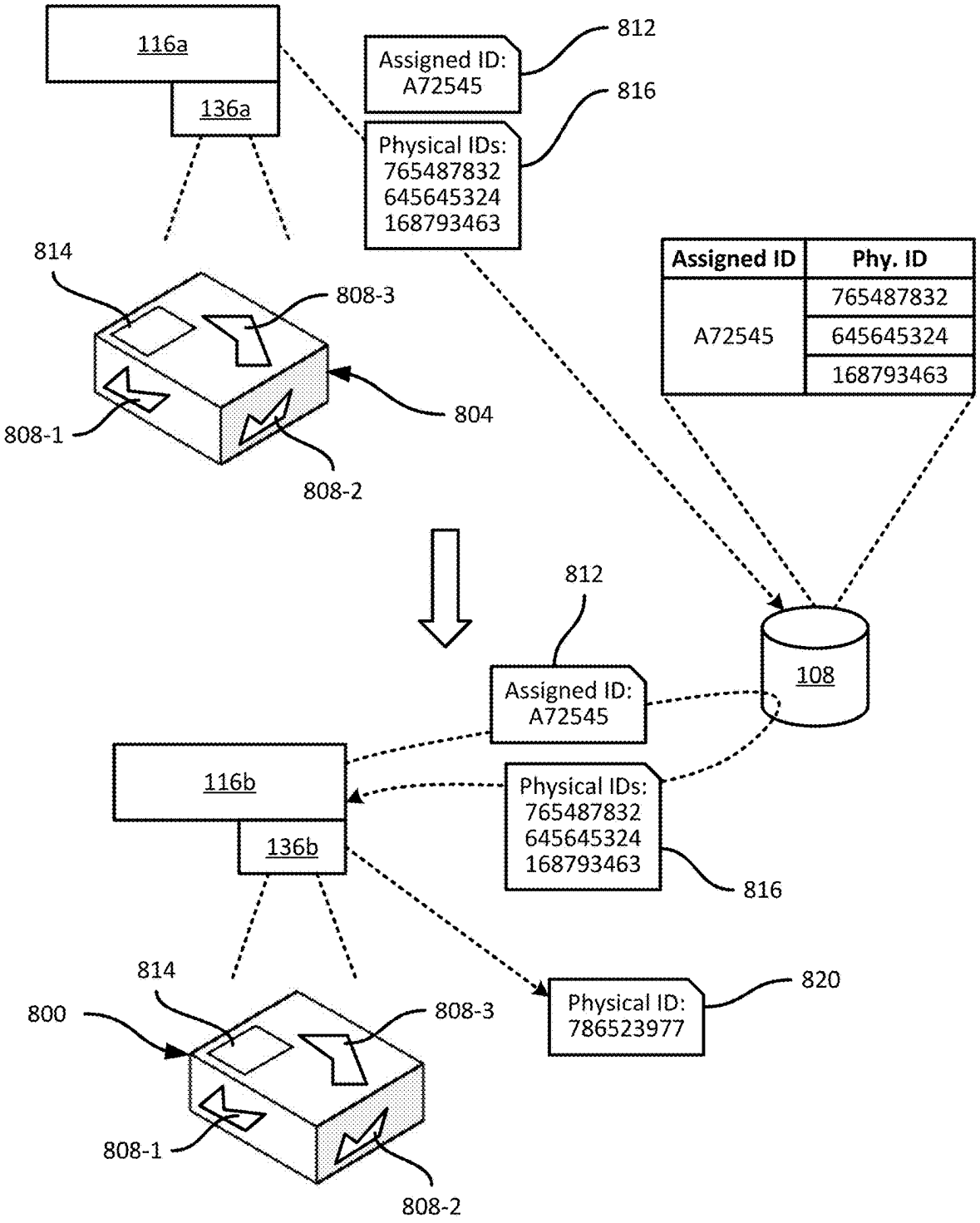

116a
136a
Assigned ID:
A72545
812
816
Physical IDs:
765487832
645645324
168793463
814
808-3
808-1
804
808-2
Assigned ID
Phy. ID
A72545
765487832
645645324
168793463
812
108
Assigned ID:
A72545
116b
136b
Physical IDs:
765487832
645645324
168793463
816
814
800
808-3
808-1
808-2
Physical ID:
786523977
820

FIG. 8

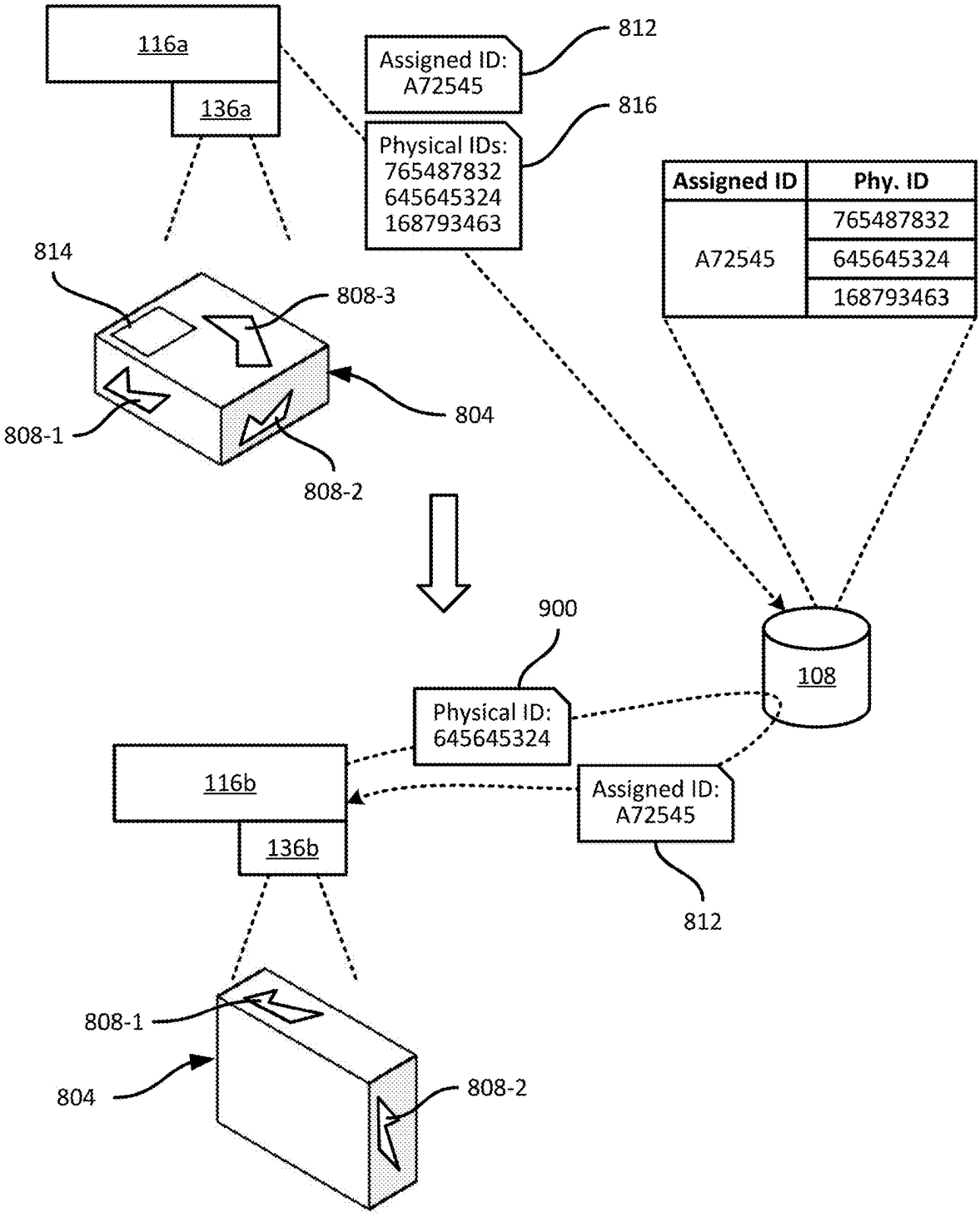

116a
136a
Assigned ID:
A72545
812
Physical IDs:
765487832
645645324
168793463
816
Assigned ID
Phy. ID
A72545
765487832
645645324
168793463
814
808-3
808-1
804
808-2
900
108
Physical ID:
645645324
116b
136b
Assigned ID:
A72545
812
808-1
804
808-2

FIG. 9

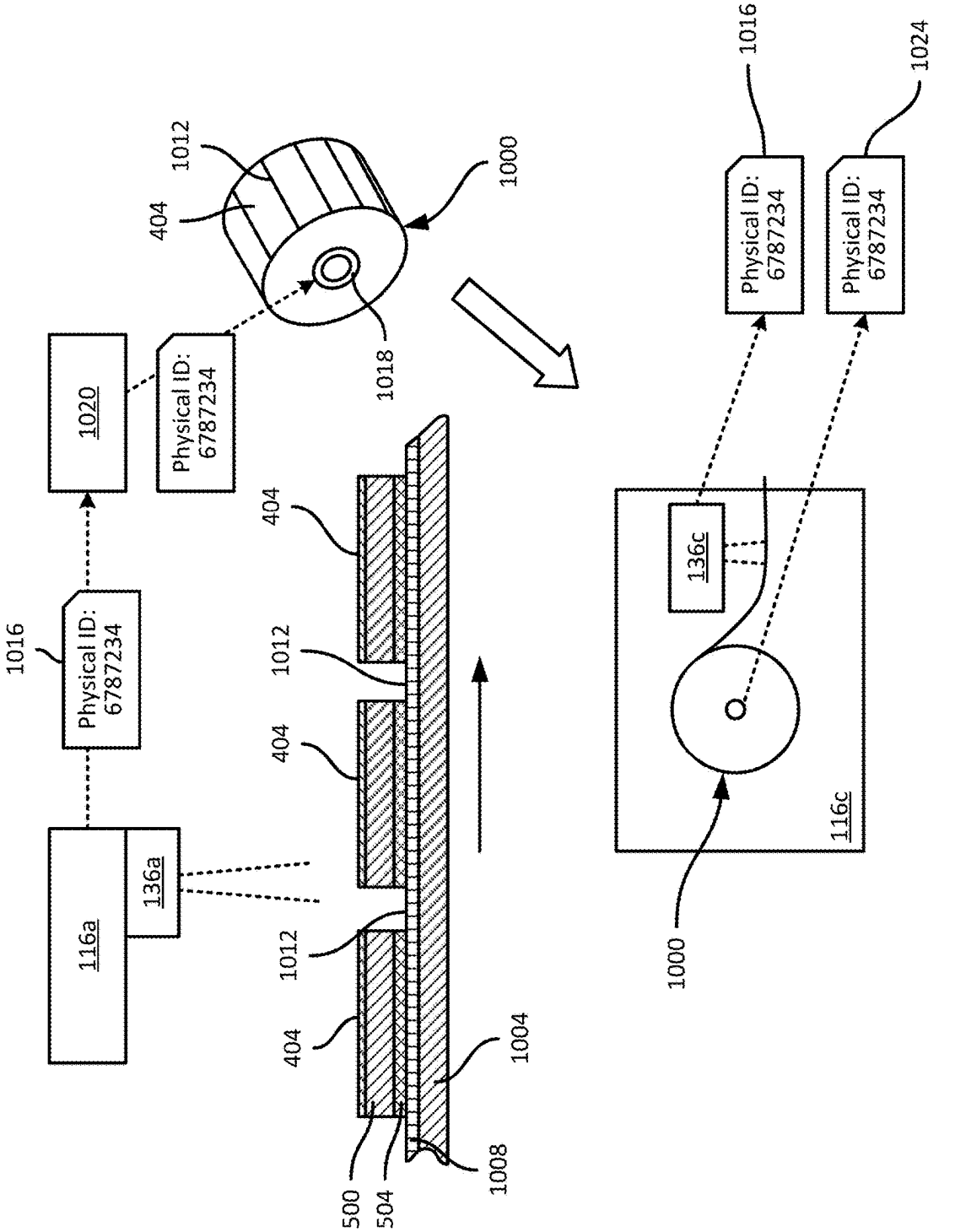

1012
404
1000
1018
1020
Physical ID: 6787234
1016
Physical ID: 6787234
116a
136a
404
1012
404
1012
404
1004
1008
500
504
1016
Physical ID: 6787234
1024
Physical ID: 6787234
136c
116c
1000

FIG. 10

OBJECT IDENTIFICATION USING SURFACE OPTICAL ARTIFACTS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of U.S. patent application Ser. No. 17/888,322, filed Aug. 15, 2022, which claims the benefit of U.S. Provisional Application No. 63/234,146, filed Aug. 17, 2021, the contents of which is incorporated herein by reference.

BACKGROUND

[0002] Objects such as packages and printing supplies may be assigned identifiers, for example to distinguish one package from others, to enable monitoring of the progress of a package during transport and delivery, to facilitate automatic setting of printer settings, and the like. Such identifiers may be encoded in barcodes or microchips, or otherwise affixed to the objects. Under certain conditions, however, decoding a barcode to retrieve an identifier assigned to an object may be impeded by lighting, position of the object, or the like, thus complicating the identification of the object. Under certain conditions, affixing a unique predetermined identifier to an object may require time and labor increasing the cost of the object above an acceptable level. Further, an identifier assigned to one object may be erroneously affixed to a different object, again complicating object identification.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0003] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate embodiments of concepts that include the claimed invention, and explain various principles and advantages of those embodiments.

[0004] FIG. **1** is a diagram of a system for object identification using surface artifacts.

[0005] FIG. **2** is a flowchart of a method for object identification using surface artifacts.

[0006] FIG. **3** is a diagram illustrating an example performance of the method of FIG. **2**.

[0007] FIG. **4** is a diagram illustrating another example performance of the method of FIG. **2**.

[0008] FIG. **5** is a cross sectional view of the label of FIG. **4**.

[0009] FIG. **6** is a flowchart of a method for object identification or authentication using physical identifiers.

[0010] FIG. **7** is a diagram illustrating an example performance of the method of FIG. **6**.

[0011] FIG. **8** is a diagram illustrating an example performance of the methods of FIG. **2** and FIG. **6**.

[0012] FIG. **9** is a diagram illustrating another example performance of the methods of FIG. **2** and FIG. **6**.

[0013] FIG. **10** is a diagram illustrating a further example performance of the methods of FIG. **2** and FIG. **6**.

[0014] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present invention.

[0015] The apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION

[0016] Examples disclosed herein are directed to a method of object identification, the method comprising: capturing an image of an object having a material presenting surface artifacts; detecting a boundary within the captured image; selecting a portion of the image depicting the surface material within the boundary; based on the selected portion of the image, determining attributes of the surface artifacts; generating, based on the determined attributes of the surface artifacts, a physical identifier corresponding to the object; and storing the generated physical identifier.

[0017] Additional examples disclosed herein are directed to a computing device, comprising: a memory; a sensor; and a processor configured to: control the sensor to capture an image of an object having a surface material presenting surface artifacts; detect a boundary within the captured image; select a portion of the image depicting the surface material within the boundary; based on the selected portion of the image, determine attributes of the surface artifacts; generate, based on the determined attributes of the surface artifacts, a physical identifier corresponding to the object; and store the generated physical identifier.

[0018] Further examples disclosed herein are directed to a label, comprising: a fibrous face stock member having surface artifacts; a uniform coating extending over a first portion of an outer surface of the face stock member, the coating configured for pigmentation responsive to a media processing operation; and a window in the coating, the window extending over a second portion of the outer surface distinct from the first portion to reveal the surface artifacts.

[0019] Still further examples disclosed herein are directed to a supply of labels, comprising: a fibrous liner layer having surface artifacts; a printable substrate layer comprising a plurality of labels separated by respective gaps; an adhesive between the fibrous liner layer and the printable substrate layer; and a data carrier encoding a physical identifier derived from at least one optical measurement of the surface artifacts of the liner layer within at least on of the gaps.

[0020] FIG. **1** illustrates a system **100** for object identification using surface optical artifacts including an object **104** having a region **112** displaying the artifacts and a computing device **116** configured to generate a physical identifier of the object **104** using the artifacts and to store the physical identifier in a repository **108**. A wide variety of objects, such as packages for transport and delivery from origin locations (e.g., retailers) to destination locations (e.g., customer residences) are identified by one or more of product numbers, order numbers, tracking numbers, and the like. Generally referred to herein as assigned identifiers, those numbers (which need not be strictly numerical, but can also include alphanumeric strings, glyphs, or characters) can be assigned to objects in various ways that are outside the scope of the present discussion. The assigned identifier of an object **104** (e.g., a box or other parcel containing one or more items for

shipment) can, for example, be stored in a repository **108** (e.g., hosted at a server or other network-connected computing device). The repository **108** can also store various other information corresponding to the object **104**, such as dimensions of the object **104**, a destination to which the object **104** is to be delivered (e.g., a mailing address), contents of the object **104**, and the like.

[0021] During transit, handling, or the like, additional information can be collected and recorded in the repository **108**, in association with the assigned identifier of the object **104**. For example, transit locations (e.g., intermediate facilities between origin and destination), may associate the assigned identifier of the object with a condition of the object **104** and record the associated condition and timestamps in the repository **108** to track the shipment of the object **104**. The assigned identifier can be affixed to the object **104** for retrieval during the collection of such additional information. For example, the assigned identifier can be printed on a label (e.g., in plain text, and/or encoded in a machine-readable indicium such as a barcode) affixed to a surface of the object **104**, or applied directly to a surface of the object **104**. In an embodiment, the assigned identifier can be printed directly on or near a surface of the object, such as ink jet marking the surface of a box or thermally printing a heat receiving area near a substrate surface but covered by a protective varnish or laminate. In an embodiment the assigned identifier can be stored in a radio frequency identification (RFID) tag affixed to or incorporated into the object **104**.

[0022] Under certain conditions, however, retrieving the assigned identifier from the object **104** may be impeded. For example, during loading of the object **104** into a vehicle for delivery, a camera or other sensor mounted in the vehicle, or operated by a driver of the vehicle, may capture images of the object **104**. The images may omit the assigned identifier, or partially include the assigned identifier. In other cases, the images may encompass the portion of the object **104** bearing the assigned identifier, but lighting or other conditions may prevent accurate decoding or other extraction of the assigned identifier. In such examples, the object **104** may be inaccurately identified, or identification of the object **104** (i.e., retrieving the assigned identifier of the object **104**) may fail. Updating status information for the object **104** in the repository **108** may therefore also fail. Similarly, a camera positioned to capture images of objects carried by a conveyor may decode a first assigned identifier from a first barcode on a top surface of a first object but may be unable to decode a second assigned identifier from a second barcode on the bottom surface of a second object.

[0023] In a scenario, high speed converting equipment producing die cut labels or corrugated cardboard boxes may require additional equipment or secondary handling to add unique identifiers to each label or box. For such objects, the additional cost of marking a unique identifier may outweigh the value obtained from use of the unique identifier.

[0024] In a scenario, the assigned identifier corresponding to the object **104** may be affixed to a different object, whether in error or maliciously (e.g., in connection with a counterfeit object). Because the assigned identifier generally does not have an inherent association with the object, it may be difficult to detect that the assigned identifier has been affixed to an object different from the object **104** to which the assigned identifier was originally associated.

[0025] The system **100** therefore includes certain components and functionality to augment identification of the object **104**, using physical attributes of the object **104**. The object **104**, as discussed in greater detail below, includes a surface material that can be sensed (e.g., imaged) by sensors exterior to the object **104** and presents surface artifacts in at least one region **112**. In proximity to the surface artifacts is a cut or printed boundary. A computing device **116** is configured to generate a physical identifier of the object **104** associated with the appearance of the physical artifacts relative to the boundary. The physical identifier can then be stored in the repository **108** in association with the assigned identifier. The physical identifier can subsequently be employed to identify an object **104** not carrying the assigned identifier, and/or to authenticate the object **104** (e.g., to ensure that an object bearing the assigned identifier is the same as the original object to which the assigned identifier was assigned), and/or to identify the object **104** in the absence of sensor data, such as a captured image or RFID tag read, enabling extraction of the assigned identifier.

[0026] The computing device **116** can be implemented as a mobile computing device (e.g., a barcode scanner, a mobile computer, a mobile printer, or the like), a fixed computing device deployed in a delivery vehicle, object handling facility, or the like. In some examples, the computing device **116** can be implemented as a media processing device such as a label printer, receipt printer, wristband printer, smartlabel printer-encoder, ID card reader, ID card printer, thermal printer, inkjet printer, offset printer, flexographic printer, or the like. The computing device **116** includes, in the illustrated example, a processor **120**, such as a central processing unit (CPU), a graphics processing unit (GPU), or a combination thereof. The processor **120** is communicatively coupled with a non-transitory computer-readable storage medium such as a memory **124**, implemented as a suitable combination of volatile and non-volatile memory elements. The memory **124** can store a plurality of computer-readable instructions, e.g., an object identification application **128** executable by the processor **120** to perform functionality discussed in greater detail below. The application **128**, in other examples, can be implemented as a suite of distinct applications, or as a dedicated hardware element (e.g., an application-specific integrated circuit (ASIC)).

[0027] The computing device **116** also includes a communications interface **132** enabling communication between the device **116** and other computing devices (e.g., a server hosting the central repository **108**), via suitable short-range links, local area or wide area networks, and the like. The interface **132** includes suitable hardware elements, executing suitable software and/or firmware, to communicate with such other computing devices.

[0028] The computing device **116** includes, or is otherwise communicatively coupled with, a sensor **136** such as a camera (e.g., configured to capture visible light, and/or light outside the visible spectrum, such as infrared or ultraviolet light). The sensor **136** can also include other optical sensors in addition to or instead of the camera, such as one or more light emitters and photodiodes arranged to measure intensity of light from the emitter(s) reflected by an object within a field of view (FOV) **140** of the sensor **136**, transmitted through the object, and/or fluoresced by the object.

[0029] As discussed in greater detail below, the computing device **116** is configured to capture an image of the object

104 (including any one or more of a two-dimensional pixel array, a linear array of intensity measurements, an array obtained by digitizing an analog sensor measurement, and the like). The computing device **116** is further configured to generate, from the captured image, a physical identifier of the object **104**. The physical identifier enables the computing device **116** itself, or other sensor-equipped computing devices, to identify and/or authenticate the object **104**.

[0030] Turning to FIG. **2**, a method **200** of object identification using surface optical artifacts is illustrated. The method **200** is described below in conjunction with its example performance within the system **100**, (e.g., by the computing device **116**).

[0031] At block **205**, the computing device **116** is configured to capture an image of the object **104**. The computing device **116** can, for example, control the sensor **136** to capture the image. As noted above, the image can include a two-dimensional array of pixels (e.g., with each pixel containing color and/or intensity values). In other examples, the image can include a one-dimensional profile including a series of intensity measurements corresponding to a particular portion of the object **104**. For example, in embodiments in which the computing device **116** is implemented as a converting press or a label printer, the device can include an optical sensor along the media path from a media supply chamber to a print head, and the image can include a series of intensity measurements (e.g., of reflected or transmitted light) taken as a web of labels travels past the sensor **136**.

[0032] In an embodiment, the web of labels may include a strip of liner material, adhesive, and label material. Individual labels are die cut from the label material and cut material is removed during the label converting process. The resulting web of labels includes a continuous strip of liner with a repeating pattern of adhesive labels separated by gap areas. The boundary of a gap area is defined as the die-cut trailing edge of a first label to the die-cut leading edge of the subsequent label. The surface material presenting surface artifacts is the exposed liner presented within the label gap area. In this embodiment each measurement in the series may correlate to sensor measurements from a portion of the web within the gap areas. Because a roll of 1000 labels may include 999 gap areas measurable by the sensor **136**, the physical identifier of the web of labels may be generated from sensor measurements from one or more gap areas. Due to random variation in the liner paper fibers, sensor measurements from different gap areas on the same web may vary, even though the gap dimensions are consistent.

[0033] However the sequence of those sensor measurements would remain consistent each time the measurement process is repeated. A second web of labels with similar liner cut from an identical die would have different random variations in the liner paper fibers, such that the first physical identifier for the first web of labels would differ from the second physical identifier for the second web of labels even if each were measured in the same way and even though the measurement for each distinct web of labels is repeatable.

[0034] At block **210**, the computing device **116** is configured to obtain the assigned identifier of the object **104**. The performance of block **210** can, in other examples, occur prior to block **205**, or later in the method **200**. Obtaining the assigned identifier can include receiving the assigned identifier as input data, e.g., via a keyboard or other input assembly of the computing device **116**. Obtaining the assigned identifier can also include detecting and decoding a barcode or other machine-readable indicium, e.g., on a label affixed to the object **104**. The machine-readable indicium can be detected and decoded from the image captured at block **205** in some examples. In other examples, the computing device **116** can obtain a separate image, optionally from a sensor distinct from the sensor **136**, and detect and decode the machine-readable indicium from the separate image. In some examples, e.g., in which the method **200** is performed in conjunction with a loading operation for a delivery vehicle, the image can be captured at block **205** by a camera disposed within or adjacent to the vehicle, and the assigned identifier can be received from an RFID reader or barcode scanner also associated with the vehicle.

[0035] Turning to FIG. **3**, example performances of blocks **205** and **210** are illustrated. An image **300** captured by the sensor **136** is shown, depicting a surface of the object **104**. The surface depicted in the image **300** includes a label **304** that includes a machine-readable indicium, from which the computing device **116** can decode an assigned identifier **308** (e.g., the string "A72545" in this example). The captured image may include only at least a portion of the surface including the machine-readable indicium, or it may stitch together multiple images captured by the sensor **136** to produce the image **300** from which the assigned identifier **308** is decoded. The assigned identifier **308** is also stored in the repository **108**, along with other information corresponding to the object, such as dimensions, a delivery address, product name(s) and count(s), and the like.

[0036] Returning to FIG. **2**, at block **215**, having captured the image **300** and obtained the assigned identifier **308**, the computing device **116** is configured to select a portion of the image **300** from block **205** for further processing. The selected portion of the image depicts a surface material of the object **104**. The surface material can include a surface material of a box forming at least portion of the object **104** (e.g., a cardboard box), a surface material of the label **304** affixed to the box, or the like. The computing device **116** can be configured, to select a portion of the image **300**, to detect a boundary presented on a surface of the object **104**, and to extract the portion of the image **300** within the boundary.

[0037] Referring again to FIG. **3**, the object **104** includes a graphic **312** printed or otherwise applied to a box of the object **104**. The graphic **312** can be a portion of a corporate logo, asymmetric mark, compliance symbol, glyph, and/or the like. In an embodiment, the graphic **312** may be printed or otherwise applied to the box along with other text or graphics such that no secondary handling is required. In addition, the graphic **312** defines a boundary enclosing a portion of a surface of the box, i.e., separating the surface inside the boundary from the surface outside the boundary. The graphic **312** can be applied with a visible pigment in some examples, but in other examples can be applied with a pigment that is detectable by the sensor **136**, but is not visible to a human. The computing device **116** can detect the graphic **312** by any suitable method, e.g., by applying computer vision feature detection techniques, by determining contrast in image intensity within the captured image **300**, by retrieving from memory a boundary definition specifying the shape or distances of the graphic **312**. Having detected the graphic **312**, the computing device **116** is configured to extract the portion of the image falling within the boundary defined by the graphic **312**. In the example of FIG. **3**, therefore, the computing device **116** is configured to extract a portion **316** of the image **300**.

[0038] As shown in FIG. **3**, the surface material of the object **104** (at least within the boundary set out above) presents surface artifacts, which have an arrangement that is random and therefore specific to each object **104**. In the illustrated example, the surface material is fibrous, such as paper, cardboard, Tyvek, or another suitable paper substrate. Cardboard and paper can be fabricated from wood fiber, but other sources of fiber can also be employed to manufacture cardboard and paper materials. For example, the fibrous materials presenting surface artifacts as discussed herein can include can also include combinations of wood-fiber materials with polymers, textiles (e.g., cotton, linen) or the like. Such fibrous materials may also be referred to as "paper", despite containing little or no wood fiber. As shown in the detailed view **320** of the graphic **312**, the lengths, color, and orientations of individual fibers **324** can vary widely. The variation in fiber length and orientation is generally randomized as a result of the manufacturing processes used to fabricate the surface material. That variation may be inherent in the manufacturing process requiring no secondary handling to create. The fibers, in other words, are surface artifacts that can be employed to generate a physical identifier specific to the object **104**

[0039] Referring again to FIG. **2**, at block **220**, the computing device **116** is configured to generate a physical identifier corresponding to the object **104** based on measurement of the surface artifacts Because a large number of surface artifacts are possible, the generated physical identifier is unlikely to repeat in a small population of objects. Either decreasing the quantity of objects in the population or increasing the precision of the measurement will further decrease the likelihood of the generated physical identifier repeating within the population of objects, so sensors with less sensitivity or precision may be used in applications requiring only limited uniqueness. In particular, the computing device **116** can be configured to determine at least one attribute of the surface artifacts (e.g., of the fibers within the boundary defined by the graphic **312**, in the example of FIG. **3**), and to generate the physical identifier based on the determined at least one attribute.

[0040] Examples of attributes determined at block **220** include fiber length and orientations as noted above. Further example attributes include fiber thickness, fiber color, intensity of light reflected from the fibers, intensity of light transmitted through the fibers, intensity of light emitted by fluorescent fibers, and the like. For example, the computing device **116** can determine a portion of the surface area within the boundary that is occupied by fibers of a certain color, thickness, or combination thereof. The portion can be used as an input to a hashing function to generate a physical identifier such as a numerical string. A wide variety of other features can be derived from the attributes of the surface artifacts, and combined to produce a physical identifier. In an embodiment, only a portion of the image **300** within the boundary proximate the graphic **312** may be measured to generate the physical identifier; for example, the sequence of thin fibers and wide fibers intersecting the border of the graphic **312** may be used to generate the physical identifier. In an embodiment, a portion of the image **300** extending across the graphic **312** may be measured to generate the physical identifier; for example, the intensity profile of the image extending from a first border edge of the graphic **312** past a plurality of fibers with various optical characteristics to a second border edge of the graphic **312** may be measured to generate the physical identifier. In the example shown in FIG. **3**, the computing device **116** generates a physical identifier **328** in the form of the string "6784923876". The physical identifier is referred to as "physical identifier", in contrast with the assigned identifier, because the physical identifier **328** reflects inherent physical characteristics of the object **104** that are generally difficult to duplicate because of the random arrangement of the surface artifacts.

[0041] At block **225**, in response to generating the physical identifier **328**, the computing device **116** is configured to store the physical identifier. In some examples, at block **225** the computing device **116** is configured to associate the assigned identifier **308** and the physical identifier **328**. Associating the assigned identifier and the physical identifier can include storing the assigned identifier and the physical identifier together (e.g., in a data record) locally in the memory **124** and/or transmitting the physical identifier to another computing device for storage thereon. For example, the computing device **116** can update the repository **108** to store the physical identifier **328** in association (e.g., in the same data record) with the assigned identifier **308**, as shown in FIG. **3**. In other examples, associating the physical and assigned identifiers need not involve long-term storage. For example, in embodiments in which the computing device **116** tracks motion of the object **104** over a relatively short timeframe (e.g., up to five minutes, up to the completion of a device activity, up until a battery of the device is discharged), the assigned and physical identifier can be maintained in memory **204** only until position tracking of the object **104** is complete, following which time the physical identifier can be discarded and the final detected position of the object **104** stored persistently in association with the assigned identifier. In further examples, storing the physical identifier at block **225** can include writing the physical identifier to a data carrier, e.g., by writing the physical identifier to an RFID tag or printing the physical identifier on a label in plain text and/or encoded in a barcode. In still further examples, at block **225** the computing device **116** can store the physical identifier independently of an assigned identifier, e.g., by writing the physical identifier to the data carrier, which is affixed to or an integral part of the object **104** itself. In such examples, block **210** can be omitted.

[0042] As such, performance of the method **200** generates a physical identifier **328** that is based on inherent physical attributes of the object **104**, and that can be regenerated later from a further image of the object **104** but that is difficult to reproduce without the object **104**.

[0043] FIG. **4** illustrates another example performance of the method **200**, in which the surface material is provided on a label affixed to a box of the object **104**, rather than on the box itself. In the example of FIG. **4**, at block **205** the computing device **116** captures an image **400** of the object **104**, in which a label **404** is visible. The label **404** can include a machine-readable indicium **408** (e.g., a barcode or RFID tag) encoding the assigned identifier. The label **404** also includes a graphic **412** defining a boundary that encloses a portion **416** of the label **404**.

[0044] At block **210**, the computing device **116** is configured to decode the assigned identifier **308** from the indicium **408**. At block **215**, the computing device **116** is configured to extract the portion **416** from the image **400**. As discussed in connection with FIG. **3**, the portion **416** depicts surface artifacts such as fibers with random lengths, orientations, and the like. From the portion **416**, the computing device **116**

determines at least one attribute of the surface artifacts, and at block **220**, generates a physical identifier **420**. At block **225**, the computing device **116** updates the repository **108** to store the physical identifier **420** in association with the assigned identifier **308**.

[0045] FIG. **5** illustrates a cross-section of the label **404** taken at the dashed line over the label **404** in FIG. **4**. The label **404** includes a face stock member **500**, e.g., made of paper or another suitable fibrous material displaying surface artifacts such as the fibers mentioned in connection with FIGS. **3** and **4**. The face stock **500** is affixed to an adhesive layer **504** configured to adhere to a box or other portion of the object **104**. The adhesive layer **504** may, prior to placement of the label **404** on the box, be removably disposed on a liner or web carrying a plurality of labels.

[0046] The label **404** further includes a coating **508** on a surface of the face stock **500** opposite the adhesive **504**. The coating **508** is uniform, in that the coating **508** exhibits fewer surface artifacts than the face stock **500** itself. The coating **508** is generally configured to accept and retain pigment, and/or can contain thermally activated pigment (e.g., for labels suitable for thermal printing).

[0047] To enable the label **404** to be used for the generation of a physical identifier, the label **404** includes a window or gap **512** in the coating **508**, to expose a portion of the face stock **500**. As shown in FIG. **5**, the portion of the face stock **500** exposed by the window **512** coincides with the portion **416** from which the physical identifier **420** was derived in the example of FIG. **4**. In other implementations, the portion **416** can be covered by a different coating (e.g., transparent to the light to which the sensor **136** is configured to collect), rather than being exposed.

[0048] The examples of FIGS. **3** and **4** can be combined in some examples. That is, the object **104** can include more than one boundary, and the computing device **116** can therefore generate more than one physical identifier for the object **104**. Each generated physical identifier is stored in association with the same assigned identifier, e.g., in the repository **108**. The use of multiple physical identifiers may facilitate the subsequent capture of at least one physical identifier for identification and/or authentication, e.g., when only some surfaces of the object **104** are visible to a sensor.

[0049] In further embodiments, e.g., in which the image captured at block **205** includes a series of intensity measurements (e.g., of reflected or transmitted light) corresponding to gaps between labels, taken as a web of labels travels past the sensor **136** prior to placement of the labels in a roll or fan-fed box, the boundary used at block **215** can be set by the manufacturing apparatus (e.g., a converting press) along which the web of labels travels. That is, the sensor **136** can be positioned over a predetermined portion of the path the web travels along. The physical identifier generated at block **220** in such examples can include a string generated from at least one of the intensity measurements. For example, a physical identifier can be generated for a roll of labels by combining the intensity measurements from a plurality of gaps between the labels in the roll. In an embodiment, a physical identifier can be generated for a roll of labels by combining a plurality of intensity measurements captured across a single gap. Turning to FIG. **6**, a method **600** of employing the physical identifier generated via the method **200** for object identification and/or authentication is illustrated. The method **600** can be performed by the computing device **116** (e.g., at a later point in time than the method **200**), or by another computing device equipped with a sensor as described in connection with the sensor **136**. The performance of the method **600** will be described below as being performed by the computing device **116**, for illustrative purposes.

[0050] At block **605**, the computing device **116** is configured to capture an image of an object **104**, as described in connection with block **205**. For example, the image captured at block **605** can be an image of an object bearing the same assigned identifier as the object **104** shown in the image **300**. It may not yet be known, however, whether the object shown in the image from block **605** is the object **104** from which the physical identifier **328** was derived. At block **610**, therefore, the computing device **116** is configured to select a portion of the image from block **605**, and at block **615** the computing device **116** is configured to determine a physical identifier from the portion selected at block **610**. The performances of blocks **610** and **615** are as described above in connection with blocks **210** and **215**.

[0051] Turning to FIG. **7**, an image **700** is shown, having been captured at block **605** and depicting a candidate object **104***a* bearing a label **704**. The computing device **116** can be configured, at block **610**, to extract a portion of the image within a boundary **708**, and to generate a physical identifier **712** based on at least one determined attribute of the surface artifacts within the extracted portion.

[0052] Returning to FIG. **6**, the physical identifier **712** determined at block **615** can be employed to identify the object **104***a*, and/or to authenticate the object **104***a*. To authenticate the object **104***a*, the computing device **116** proceeds to block **620**. At block **620**, the computing device **116** is configured to retrieve an expected physical identifier for the object **104***a*. To retrieve the expected physical identifier, the computing device **116** can obtain an assigned identifier from the object **104***a*, e.g., by decoding a machine readable indicium on the label **704**. FIG. **7** shows that the assigned identifier **308** is obtained from the label **704**. For example, the label **704** may encode the same data as the label **304** shown in FIG. **3**.

[0053] Using the assigned identifier **308**, the computing device **116** can retrieve the expected physical identifier for the object **104***a* from the repository **108**, the memory **204**, or another storage device. In other examples, the computing device **116** can obtain the expected physical identifier from the object **104***a*. For example, in some embodiments the physical identifier generated at block **220** is printed (at block **225**) on the object **104***a*, written to an RFID tag affixed to the object **104***a*, or the like. In those embodiments, the computing device **116** can decode or otherwise read the expected physical identifier at block **620** from the RFID tag, barcode, or the like.

[0054] At block **625**, the computing device **116** is then configured to compare the physical identifier determined from block **615** with the expected physical identifier obtained from block **620**. When the physical identifiers from blocks **615** and **620** match, the computing device **116** is configured to authenticate the object **104***a* at block **630**. That is, at block **630** the computing device **116** has verified that the object **104***a* is the same physical object as the object **104**. The computing device **116** can generate an authentication notification, generate an event, store the verification to memory, provide indication to a user, continue with a processing operation, or the like.

[0055] When the determination at block **625** is negative, however, as is the case in the example of FIG. **7** (because the determined physical identifier **712** does not match the physical identifier obtained from the repository **108**), the computing device **116** is configured to proceed to block **635**. At block **635**, the computing device **116** is configured to generate an exception, e.g. by notifying an operator or another computing device that the object **104***a* is not authenticated. That is, the exception indicates that the object **104***a* is not the same physical object as the object **104**, despite bearing the same assigned identifier. The object **104***a* may therefore be a counterfeit, or may have been improperly processed.

[0056] As noted above, the computing device **116** can also use the physical identifier determined from block **615** to retrieve an assigned identifier, for example when the assigned identifier cannot be obtained from the object **104***a* (e.g., because the label is obscured). At block **640**, the computing device **116** can query the repository **108** for the assigned identifier corresponding to the physical identifier determined from block **615**. Upon obtaining an assigned identifier, the computing device **116** can output the assigned identifier, e.g., to a position tracking application that captures a sequence of images and tracks the position of the object **104** therein.

[0057] Turning to FIG. **8**, an example implementation of the methods **200** and **600** is shown to authenticate a candidate object **800**. A computing device **116***a*, via control of a sensor **136***a*, is configured to perform the method **200**. For example, the sensor **136***a* can capture one or more images of an object **804** (at block **205**) having boundaries **808-1**, **808-2**, and **808-3** on respective faces thereof. The object **804** can include one or more boundaries **808** on each face. The object **804** may, for example, be presented to the sensor **136***a* in a plurality of orientations for the capture of images depicting each of the boundaries **808**. At block **210**, the computing device **116***a* can also obtain an assigned identifier **812**, e.g., by detecting and decoding a barcode from a label **814** in the images, by receiving the assigned identifier **812** from an RFID reader, or the like. At blocks **215** and **220**, the computing device **116***a* is configured to generate a physical identifier for each of the graphics **808** (that is, a physical identifier derived from the surface artifacts displayed by fibrous material of the object **804** within the boundaries **808**). The computing device **116***a* can then store, at block **225**, the physical identifiers **816**, e.g., by sending the physical identifiers **816** and the assigned identifier **812** to the repository for storage.

[0058] Subsequently, e.g., in response to arrival of the candidate object **800** at a handling facility or the like, a further computing device **116***b* can be configured to perform the method **600** to authenticate the candidate object **800**. For example, via blocks **605** to **615**, the computing device **116***b* can control the sensor **136***b* to capture one or more images. For example, the sensor **136***b* can capture an image depicting the boundary **808-3** (and the label **814**). From the captured image, the computing device **116***b* can determine (at block **615**) a physical identifier **820**. At block **620**, the computing device **116***b* can determine the assigned identifier **812**, e.g., from the captured image, and use the assigned identifier **812** to query the repository for expected physical identifiers **816**. The computing device **116***b* can then compare the determined physical identifier **820** to the expected physical identifiers at block **625**. As shown in FIG. **8**, the determined physical identifier **820** does not match any of the expected physical identifiers **816**, and the computing device **116***b* generates an exception at block **635**, e.g., indicating that the candidate object **800** is not the same object as the object **804**, despite bearing the same assigned identifier **812**.

[0059] FIG. **9** illustrates another example performance of the methods **200** and **600** to identify the object **804**, e.g., at distinct stages in the transport and/or handling of the object **804**. As described in connection with FIG. **8**, via the performance of the method **200**, the computing device **116***a* can generate the physical identifiers **816** and store the physical identifiers **816** in association with the assigned identifier **812** in the repository **108**. In other examples, the association between the physical identifiers **816** and assigned identifier **812** can be stored in the local memory of the computing device **116***a*.

[0060] In response to arrival of the object **804** at a handling facility or the like, the computing device **116***b* can capture an image of the object **804** and determine a physical identifier **900** from the image, via blocks **605** to **615**. Due to the orientation of the object **804**, obstructions between the object **804** and the sensor **136***b*, or other imaging conditions, the image(s) captured by the sensor **136***b* may not depict the label **814**, and the assigned identifier **812** may not be derivable directly from the captured image(s). The computing device **116***b* can, at block **640**, query the repository **108** (or local memory, in some examples) using the determined physical identifier **900**, and retrieve the assigned identifier **812** (since the determined physical identifier **900** matches one of the physical identifiers **816** previously generated by the computing device **116***a*).

[0061] FIG. **10** illustrates a further example performance of the methods **200** and **600** to authenticate a supply of labels **1000**, such as a roll of labels. The roll can be produced by converting equipment producing die cut labels that are then spooled to produce the roll **1000**. FIG. **10** shows a partial cross section of the labels prior to rolling, in which a plurality of labels **404** (as described earlier in connection with FIG. **4**, although the boundary **412** and window **512** may be omitted) formed by a paper substrate layer **500** with an adhesive backing **504**. The adhesive **504** lies between the paper substrate and a liner layer **904**, e.g., a fibrous liner such as paper or another suitable material. The web of labels may include a layer **1008** between the fibrous liner **1004** and the adhesive **504**, e.g., a layer of silicone to facilitate removal of the labels **404** from the liner **1004** for use.

[0062] Between each label **404**, the web includes a gap **1012** at which the liner **1004** is visible through the translucent or transparent layer **1008**. A computing device **116***a*, e.g., mounted over a portion of the production line that the web travels past, can capture images of one or more of the gaps **1012** (up to and including all of the gaps **1012** for a given web), and generate a physical identifier **1016** for the supply **1000**, or a series of physical identifiers (e.g., one per gap **1012**). The computing device **116***a* can transmit the physical identifier **1016** to a marking apparatus **1020**, configured to encode the physical identifier **1016** in a data carrier on the supply **1000**. The data carrier can be an RFID tag, e.g., affixed to a core **1018** of the supply **1000**. The data carrier can also be a barcode applied to the supply **1000**. The RFID tag or barcode may be affixed to the inside of the core **1018**, the end of the core **1018**, the surface of the core adjacent the label web, manufactured into the core **1018**, or affixed to a cartridge associated with the supply. In an

embodiment the data carrier may be printed on the inside of the core **1018**, the end of the core **1018**, the surface of the core adjacent the label web, the liner **1004**, the label **404**, or a cartridge associated with the supply.

[0063] Following manufacture of the supply **1000**, the supply **1000** can be installed in a further computing device **116***c* such as a printer, having a sensor **136***c* disposed along a media path. As the media is fed from the supply **1000** to a print head or other media processing element(s) in the device **116***c*, the sensor **136***c* can capture image(s) of the gaps **1012** (i.e., performing blocks **605** to **615**) and thereby determine a physical identifier **1024**. The device **116***c* can also, at block **620**, obtain an expected physical identifier (i.e., the physical identifier **1016**) from the data carrier mentioned above. At block **625**, the device **116***c* can compare the expected physical identifier **1024** with the determined physical identifier **1016**. When the physical identifiers **1016** and **1024** match, as shown in FIG. **10**, the supply **1000** is authenticated. When the physical identifiers **1016** and **1024** do not match, the device **116***c* may interrupt printing at block **635**, or generate another suitable exception. When a series of expected physical identifiers **1024** are generated and encoded by the device **116***a*, the device **116***c* can determine whether a threshold portion (e.g., 75%, or any other suitable portion) of determined physical identifiers **1016** match the expected physical identifiers **1024**.

[0064] In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

[0065] The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

[0066] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has", "having," "includes", "including," "contains", "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises . . . a", "has . . . a", "includes . . . a", "contains . . . a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein. The terms "substantially", "essentially", "approximately", "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0067] Certain expressions may be employed herein to list combinations of elements.

[0068] Examples of such expressions include: "at least one of A, B, and C"; "one or more of A, B, and C"; "at least one of A, B, or C"; "one or more of A, B, or C". Unless expressly indicated otherwise, the above expressions encompass any combination of A and/or B and/or C.

[0069] It will be appreciated that some embodiments may be comprised of one or more specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches could be used.

[0070] Moreover, an embodiment can be implemented as a computer-readable storage medium having computer readable code stored thereon for programming a computer (e.g., comprising a processor) to perform a method as described and claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read Only Memory), an EPROM (Erasable Programmable Read Only Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and a Flash memory. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

[0071] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are

hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

1. A method of object identification, the method comprising:
capturing an image of an object having a material displaying surface artifacts;
detecting a boundary within the captured image;
selecting a portion of the image depicting the material within the boundary;
determining, based on the selected portion of the image, at least one attribute of the surface artifacts;
generating, based on the determined at least one attribute of the surface artifacts, a physical identifier corresponding to the object; and
storing the generated physical identifier.

2. The method of claim **1**, wherein
the surface material is fibrous; and
the at least one attribute of the surface artifacts include at least one attribute selected from: fiber length, fiber color, fiber orientation, intensity of light reflected from fibers, intensity of light transmitted through fibers, intensity of light emitted by fibers.

3. The method of claim **2**, wherein the surface material includes a paper substrate.

4. The method of claim **1**, wherein capturing the image includes capturing one or more image, and wherein the method further comprises:
detecting an additional boundary within the one or more images;
selecting an additional portion of the one or more images depicting the material within the additional boundary;
generating an additional physical identifier based on the selected additional portion; and
storing the generating additional physical identifier in association with the physical identifier.

5. The method of claim **1**, wherein detecting the boundary includes:
retrieving a stored boundary definition; and
identifying a boundary matching the stored boundary definition in the image.

6. The method of claim **1**, further comprising:
obtaining an assigned identifier corresponding to the object;
wherein storing the physical identifier includes storing the physical identifier in association with the assigned identifier.

7. The method of claim **6**, further comprising:
capturing a second image of a candidate object;
selecting a portion of the second image;
determining at least one attribute of surface artifacts in the selected portion of the second image; and
generating a second physical identifier based on the determined at least one attribute of the surface artifacts in the selected portion of the second image.

8. The method of claim **7**, further comprising: retrieving and outputting the associated assigned identifier.

9. The method of claim **7**, further comprising:
obtaining the assigned identifier with the second image;
retrieving, based on the assigned identifier, the stored physical identifier; and
comparing the retrieved stored physical identifier with the second physical identifier to authenticate the candidate object.

10. A computing device, comprising:
a memory;
a sensor; and
a processor configured to:
control the sensor to capture an image of an object having a surface material presenting surface artifacts;
detect a boundary within the captured image;
select a portion of the image depicting the surface material within the boundary;
determine, based on the selected portion of the image, at least one attribute of the surface artifacts;
generate, based on the determined at least one attribute of the surface artifacts, a physical identifier corresponding to the object; and
store the generated physical identifier.

11. The computing device of claim **10**, wherein
the surface material is fibrous; and
the at least one attribute of the surface artifacts include at least one attribute selected from: fiber length, fiber color, fiber orientation, intensity of light reflected from fibers, intensity of light transmitted through fibers, intensity of light emitted by fibers.

12. The computing device of claim **11**, wherein the surface material includes a paper substrate.

13. The computing device of claim **10**, wherein the processor is configured to control the sensor to capture one or more image, and wherein the processor is further configured to:
detect an additional boundary within the one or more images;
select an additional portion of the one or more images depicting the material within the additional boundary;
generate an additional physical identifier based on the selected additional portion; and
store the generating additional physical identifier in association with the physical identifier.

14. The computing device of claim **10**, wherein the processor is configured to detect the boundary by:
retrieving a stored boundary definition; and
identifying a boundary matching the stored boundary definition in the image.

15. The computing device of claim **10**, wherein the processor is further configured to:
obtain an assigned identifier corresponding to the object;
store the physical identifier by storing the physical identifier in association with the assigned identifier.

16. The computing device of claim **15**, wherein the processor is configured to:
capture a second image of a candidate object;
select a portion of the second image;
determine at least one attribute of surface artifacts in the selected portion of the second image; and
generate a second physical identifier based on the determined at least one attribute of the surface artifacts in the selected portion of the second image.

17. The computing device of claim **16**, wherein the processor is configured to: retrieve and output the associated assigned identifier.

18. The computing device of claim **16**, wherein the processor is configured to:
obtain the assigned identifier with the second image;
retrieve, based on the assigned identifier, the stored physical identifier; and

compare the retrieved stored physical identifier with the second physical identifier to authenticate the candidate object.

19. A label, comprising:

a fibrous face stock member having surface artifacts;

a uniform coating extending over a first portion of an outer surface of the face stock member, the coating configured for pigmentation responsive to a media processing operation; and

a window in the coating, the window extending over a second portion of the outer surface distinct from the first portion to reveal the surface artifacts.

20. The label of claim **19**, wherein the window is defined by a portion of the coating cut away from the face stock.

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