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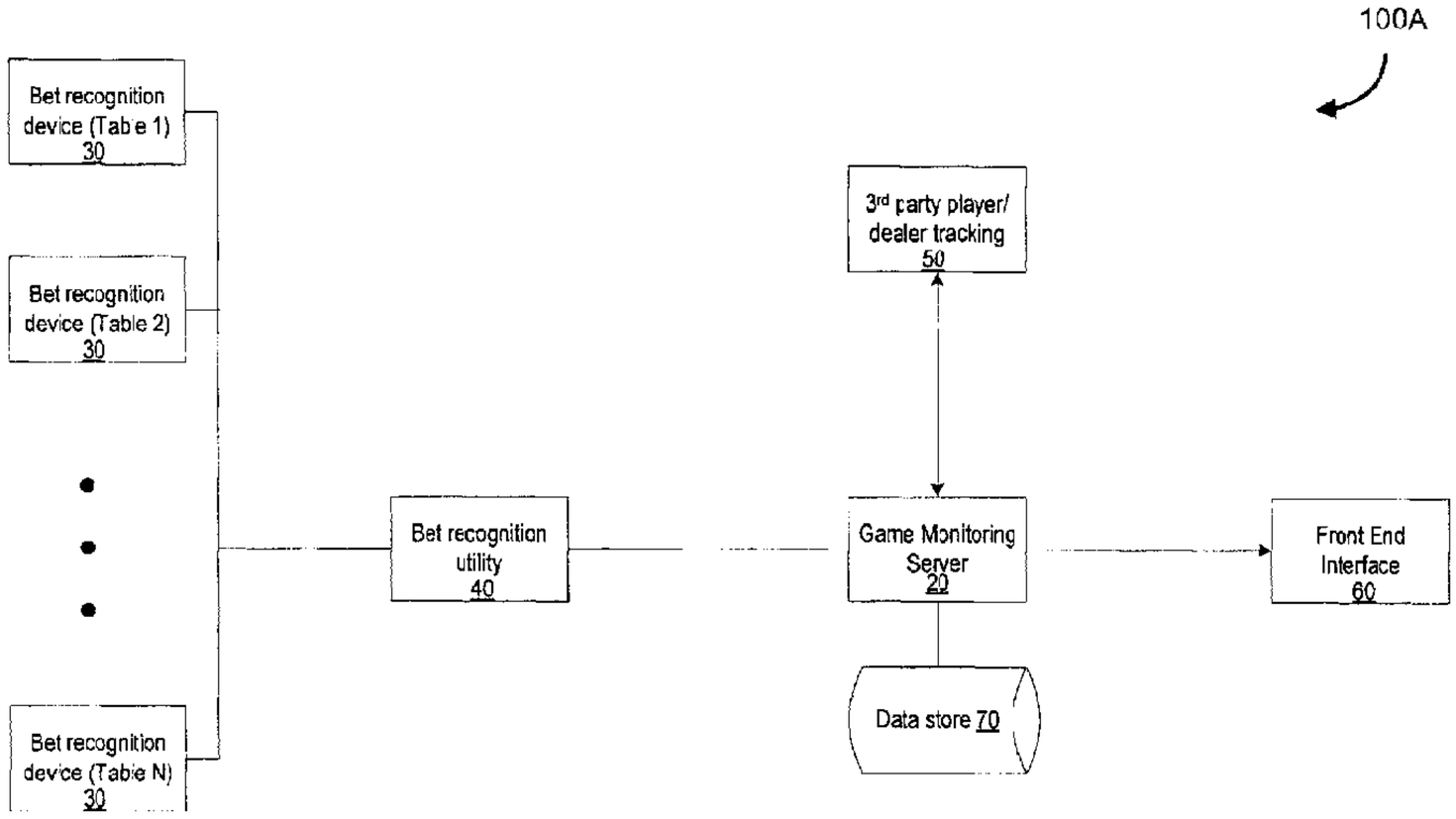
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(57) Abrégé/Abstract:
System, processes and devices for monitoring betting activities using bet recognition devices and a server. Each bet recognition device has an imaging component for capturing image data for a gaming table surface The bet recognition device receives calibration data for calibrating the bet recognition device. A server processor coupled to a data store processes the image data received from the bet recognition devices over the network to detect, for each betting area, a number of chips and a final bet value for the chips.

ABSTRACT

System, processes and devices for monitoring betting activities using bet recognition devices and a server. Each bet recognition device has an imaging component for capturing image data for a gaming table surface. The bet recognition device receives calibration data for calibrating the bet recognition device. A server processor coupled to a data store processes the image data received from the bet recognition devices over the network to detect, for each betting area, a number of chips and a final bet value for the chips.

SYSTEMS, METHODS AND DEVICES FOR MONITORING BETTING ACTIVITIES

FIELD

[0001] Embodiments generally relate to the field of monitoring game activities at gaming tables in casinos and other gaming establishments, and in particular, to monitoring game activities including betting activities.

INTRODUCTION

[0002] Casinos and gaming establishments may offer a variety of card games to customers. Card games involve various game activities, such as card play and betting, for example. A card game may be played at a gaming table by players, including a dealer and one or more customers. It may be desirable for casinos or gaming establishments to monitor betting activities for security and management purposes.

[0003] Gaming establishments are diverse in layouts, lighting, and security measures, among others. For example, betting markers, such as chips, may have varying designs and markings that not only distinguish between chip types (e.g., chip values), but also different series of chips having the same values (e.g., to reduce the risk counterfeiting and/or to enable tracking).

SUMMARY

[0004] In an aspect, there is provided a system for monitoring game activities at a plurality of gaming tables comprising: a plurality of client hardware devices for the plurality of gaming tables, each client hardware device comprising an imaging component positioned on a respective gaming table or proximate thereto to capture image data corresponding to the one or more chips positioned in a betting area on a gaming surface of the respective gaming table and, in response, pre-processing the captured image data to generate a compressed set of image data free of background image data, each client hardware device comprising one or more sensors responsive to activation events and deactivation events to trigger capture of the image data by the imaging component; a game monitoring server for collecting, processing and aggregating the compressed image data from the client hardware devices to generate aggregated betting data for the plurality of gaming tables; and a front end interface device for displaying the aggregated betting data from the game monitoring server for provision to or display on end user systems, the

front end interface device for receiving control commands from the end user systems for controlling the provision or display of the aggregated betting data.

[0005] In another aspect, the imaging component is positioned to capture the image data at an offset angle relative to a plane of the gaming surface of the respective gaming table; and wherein the offset angle permits the imaging component to capture the image data from sidewalls of the one or more chips.

[0006] In another aspect, the offset angle is an angle selected from the group of angles consisting of about -5 degrees, about -4 degrees, about -3 degrees, about -2 degrees, about -1 degrees, about 0 degrees, about 1 degrees, about 2 degrees, about 3 degrees, about 4 degrees, and about 5 degrees; and the altitude is an altitude selected from the group of altitudes consisting of about 0.2 cm, about 0.3 cm, about 0.4 cm, about 0.5 cm, about 0.6 cm, about 0.7 cm, about 0.8 cm, about 0.9 cm, and about 1.0 cm.

[0007] In another aspect, the system further comprises an illumination strip adapted to provide a reference illumination on the one or more chips, the illumination strip positioned at a second substantially horizontal angle to provide illumination on the sidewalls of the one or more chips; the second substantially horizontal angle selected such that the presence of shadows on the one or more chips is reduced.

[0008] In another aspect, the illumination strip is controllable by the client hardware devices and configured to provide the reference illumination in accordance with control signals received from the client hardware devices; the control signals, when processed by the illumination strip, cause the illumination strip to change an intensity of the reference illumination based at least on ambient lighting conditions, the control signals adapted to implement a feedback loop wherein the reference illumination on the one or more chips is substantially constant despite changes to the ambient lighting conditions.

[0009] In another aspect, the one or more sensors are adapted to determine one or more depth values corresponding to one or more distances from a reference point to the one or more chips, each of the depth values corresponding to the distance to a corresponding chip.

[0010] In another aspect, the one or more sensors determine the one or more depth values by using at least one of Doppler radar measurements, parallax measurements, infrared

thermography, shadow measurements, light intensity measurements, relative size measurements, and illumination grid measurements.

[0011] In another aspect, the one or more sensors include at least two sensors configured to determine the one or more depth values by measuring stereo parallax.

[0012] In another aspect, at least one of the client hardware devices and the game monitoring server are configured to determine a presence of one or more obstructing objects that are partially or fully obstructing the one or more chips from being sensed by the one or more sensors, the presence of the one or more obstructing objects being determined by continuously monitoring the one or more depth values to track when the one or more depth values abruptly changes responsive to the obstruction.

[0013] In another aspect, at least one of the client hardware devices and the game monitoring server are configured to, responsive to positively determining the presence of the one or more obstructing objects that are partially or fully obstructing the one or more chips from being sensed by the one or more sensors, aggregate a plurality of captured images over a duration of time and to compare differences between each of the plurality of captured images to estimate the presence of the one or more chips despite the presence of the one or more obstructing objects that are partially or fully obstructing the one or more chips from being sensed by the one or more sensors.

[0014] In another aspect, the compressed set of image data free of background image data is obtained by using an estimated chip stack height in combination with the more one or more depth values to determine a chip stack bounding box that is used for differentiating between the background image data and chip image data during the pre-processing.

[0015] In another aspect, the game monitoring server is configured to process the compressed set of image data free to individually identify one or more specific chips of the one or more chips within the chip stack bounding box represented by the compressed set of image data, each specific chip being identified through a chip bounding box established around the pixels representing the specific chip.

[0016] In another aspect, the game monitoring server is configured to identify one or more chip values associated with each of the one or more chips within the chip stack bounding box by estimating a chip value based on machine-vision interpretable features present on the one or more chips.

[0017] In another aspect, the game monitoring server is configured to identify the one or more chip values by generating one or more histograms, each of histogram corresponding with image data in the corresponding chip bounding box, by processing the one or more histograms to obtain one or more waveforms, each waveform corresponding to a histogram; and the game monitoring server is configured to perform feature recognition on each waveform to compare each waveform against a library of pre-defined reference waveforms to estimate the one or more chip values through identifying the pre-defined reference waveform that has the greatest similarity to the waveform.

[0018] In another aspect, the processing of the one or more histograms to obtain the one or more waveforms includes at least performing a Fourier transformation on the one or more histograms to obtain one or more plots decomposing each histogram into a series of periodic waveforms which in aggregation form the histogram.

[0019] In another aspect, the machine-vision interpretable features present on the one or more chips include at least one of size, shape, pattern, and color.

[0020] In another aspect, the machine-vision interpretable features present on the one or more chips include at least one of size, shape, pattern, and color and the one or more waveforms differ from one another at least due to the presence of the machine-vision interpretable features.

[0021] In another aspect, the activation events and deactivation events comprising placement and removal of the one or more chips within a field of view of the imaging component.

[0022] In another aspect, the activation events and deactivation events are triggered by a signal received from an external transmitter, the external transmitter being a transmitting device coupled to a dealer shoe that transmits a signal whenever the dealer shoe is operated.

[0023] In another aspect, the system further includes an interface engine adapted to provision an interface providing real or near-real-time betting data to a dealer, the real or near-real-time betting data based on the betting data extracted by the game monitoring server from the captured image data, the betting data including one or more estimated values for each stack of chips in one or more betting areas of the gaming surface.

[0024] In another aspect, there is provided a system for monitoring game activities comprising: a game monitoring server for collecting, processing and aggregating betting data from a plurality

of client hardware devices to generate aggregated betting data for a plurality of gaming tables, each client hardware device having at least one imaging component positioned substantially parallel to a gaming surface of a respective gaming table and configured to capture image data corresponding to one or more chips positioned on the gaming surface in response to activation events, the betting data derived from the image data; and a front end interface device for displaying the aggregated betting data from the game monitoring server for provision to or display on end user systems, the front end interface device for receiving control commands from the end user systems for controlling the provision or display of the aggregated betting data.

[0025] In another aspect, the imaging component is positioned to capture the image data at an offset angle relative to a plane of the gaming surface of the respective gaming table; and wherein the offset angle permits the imaging component to capture the image data from sidewalls of the one or more chips.

[0026] In another aspect, there is provided a device for monitoring game activities at a plurality of gaming tables comprising: an imaging component positioned on a respective gaming table or proximate thereto to capture image data corresponding to the one or more chips positioned in a betting area on a gaming surface of the respective gaming table and, in response, pre-processing the captured image data to generate a compressed set of image data free of background image data, each client hardware device comprising one or more sensors responsive to activation events and deactivation events to trigger capture of the image data by the imaging component, the imaging component positioned substantially parallel to a gaming surface of the respective gaming table; a processor configured to pre-process the captured image data to generate a compressed set of image data free of background image data responsive to activation events and deactivation events to trigger collection of betting events; and a communication link configured for transmitting the compressed set of image data to a game monitoring server configured to generate aggregated betting data for the plurality of gaming tables, the generated aggregated betting data being provided to a front end interface device configured for displaying the aggregated betting data from the game monitoring server for provision to or display on end user systems, the front end interface device configured for receiving control commands from the end user systems for controlling the provision or display of the aggregated betting data.

[0027] In another aspect, there is provided a method for monitoring betting activities comprising: detecting, by an imaging component, that one or more chips have been placed in one or more defined bet areas on a gaming surface, each chip of the one or more chips having one or

more visual identifiers representative of a face value associated with the chip, the one or more chips arranged in one or more stacks of chips; capturing, by the imaging component, image data corresponding to the one or more chips positioned on the gaming surface, the capturing triggered by the detection that the one or more chips have been placed in the one or more defined bet areas; transforming, by an image processing engine, the image data to generate a subset of the image data relating to the one or more stacks of chips, the subset of image data isolating images of the one or more stacks from the image data; recognizing, by an image recognizer engine, the one or more chips composing the one or more stacks, the recognizer engine generating and associating metadata representative of (i) a timestamp corresponding to when the image data was obtained, (ii) one or more estimated position values associated with the one or more chips, and (iii) one or more face values associated with the one or more chips based on the presence of the one or more visual identifiers; segmenting, by the image recognizer engine, the subset of image data and with the metadata representative of the one or more estimated position values with the one or more chips to generate one or more processed image segments, each processed image segment corresponding to a chip of the one or more chips and including metadata indicative of an estimated face value and position; and determining, by a game monitoring engine, one or more bet data values, each bet data value corresponding to a bet area of the one or more defined bet areas, and determined using at least the number of chips visible in each of the one or more bet areas extracted from the processed image segments and the metadata indicative of the face value of the one or more chips.

[0028] In another aspect, the method further comprises transmitting, the one or more bet data values corresponding to the one or more defined bet areas, to a gaming data repository, the game data repository configured for associating the one or more bet data values to one or more bets made by one or more players as the one or more players interact with a game being played on the gaming surface; and generating, on a display of a computing device by n interface component, an electronic dashboard illustrative of at least one of current and historical bets made by the one or more players.

[0029] Many further features and combinations thereof concerning embodiments described herein will appear to those skilled in the art following a reading of the instant disclosure.

DESCRIPTION OF THE FIGURES

[0030] In the figures:

[0031] **FIG. 1A** and **1B** illustrate a block diagrams of a system for monitoring betting activities at gaming tables according to some embodiments.

[0032] **FIG. 2** illustrates a block diagram of another system for monitoring game activities at gaming tables according to some embodiments.

[0033] **FIG. 3** illustrates a block diagram of another system for monitoring game activities at gaming tables according to some embodiments.

[0034] **FIGS. 4A-4C** illustrates a schematic diagram of bet regions monitored by a bet recognition device according to some embodiments.

[0035] **FIGS. 5** to **7** illustrate example images taken from a bet recognition device mounted on a gaming table according to some embodiments.

[0036] **FIGS. 8** and **9** illustrate example images of a bet recognition device mounted on a gaming table according to some embodiments.

[0037] **FIGS. 10** and **11** illustrate example images of a bet recognition device according to some embodiments.

[0038] **FIG. 12** illustrate a schematic diagram of another example bet recognition device according to some embodiments.

[0039] **FIGS. 13A, 13B** and **14** illustrate example images from a bet recognition device and processed images after transformation by server according to some embodiments.

[0040] **FIG. 15** illustrates a schematic diagram of a sensor array device for bet recognition device according to some embodiments.

[0041] **FIG. 16** illustrates a schematic graph of the amplitude of the received signal over time according to some embodiments.

[0042] **FIG. 17** illustrates a schematic of a game monitoring server according to some embodiments.

[0043] **FIG. 18** illustrates a schematic of a bet recognition device according to some embodiments.

[0044] **FIGS. 19-23, 24A-24D, 25A-25E, 26** to **39** illustrate schematic diagrams of bet recognition devices with camera layouts according to some embodiments.

[0045] **FIG. 40** to **43** illustrate schematic diagrams of shoe devices according to some embodiments.

[0046] **FIGS. 44, 45, 46A-46C** illustrate schematic diagrams of bet recognition devices with shoe devices according to some embodiments.

[0047] **FIGS. 47** to **50** illustrate schematic diagrams of chip stacks according to some embodiments.

[0048] **FIGS. 51** and **52** illustrate schematic diagrams of bet recognition devices with camera layouts according to some embodiments.

[0049] **FIGS. 53-56** are sample workflows, according to some embodiments.

DETAILED DESCRIPTION

[0050] Embodiments described herein relate to systems, methods and devices for monitoring game activities at gaming tables in casinos and other gaming establishments. For example, embodiments described herein relate to systems, methods and devices for monitoring card game activities at gaming tables. Each player, including the dealer and customer(s), may be dealt a card hand. Embodiments described herein may include devices and systems particularly configured to monitor game activities that include betting activities at gaming tables to determine bet data including a number of chips in a betting area of the gaming table and a total value of chips in the betting area.

[0051] The player bet data may be used by casino operators and third parties for data analytics, security, customer promotions, casino management, and so on. Games are not

necessarily limited to card games, and may include dice games, event betting, other table games, among others.

[0052] In accordance with an aspect of embodiments described herein, monitoring devices may be used to retrofit gaming tables. The monitoring devices may be integrated with the gaming tables to provide a smooth working area in a manner that does not catch on cards or chips. The monitoring device may not require changing of a gaming table top as it may be integrate within existing table top structure. An example of a monitoring device is a bet recognition device, as described herein.

[0053] Tracking bet activities that are on-going at a gaming facility is a non-trivial task that has myriad financial consequences. Accurate bet tracking is important as it may be used to more closely monitor the revenues and outflows of the gaming facility, identify patterns (e.g., theft, collusion), and provide an enhanced gaming experience. For example, tracked bet information, in the form of betting records, may be used to determine compensation levels for loyal players (e.g., the accurate provisioning of "comps" in relation to overall casino returns), rebates, etc., or track dealer and/or game performance.

[0054] Bets are often performed in conjunction with games (e.g., baccarat, poker, craps, roulette) or events (e.g., horse racing, professional sports, political outcomes), and traditionally, some bets are placed with the aid of specially configured markers (e.g., chips). These bet markers may have various markings on them, and are often distinguished from one another so that it is easy to track the value of each of the markers (e.g., denominations, characteristics). Some of the markers are designed with a particular facility in mind, and accordingly, may vary from facility to facility. For example, facilities may include casinos, gaming halls, among others.

[0055] Betting markers, such as chips, may have varying designs and markings that not only distinguish between chip types (e.g., chip values), but also different series of chips having the same values (e.g., to reduce the risk counterfeiting and/or to enable tracking). For example, such variations may be purposefully and periodically introduced such that counterfeiters may have a harder time successfully copying chip designs.

[0056] Accordingly, a flexible implementation may be preferable so that a diverse range of conditions and chips can be used with the system. For example, in some embodiments, a system is provided that is configured for interoperation with a diverse range of chip types, and

also to flexibly adapt in view of modifications to chip designs and markings. In such embodiments, the system is not "hard coded" to associate specific designs and markings with chip values, but rather, applies machine-learning to dynamically associate and create linkages as new chip types are introduced into the system. Interoperability may be further beneficial where a single system can be provisioned to different gaming facilities having different needs and environments, and the system may, in some embodiments, adapt flexibly in response to such differences (e.g., by modifying characteristics of a reference illumination on the chips, adapting defined feature recognition linkages, adapting imaging characteristics, image data processing steps, etc.).

[0057] The bet markers, such as chips, are often provided in physical form and placed individually or in "stacks" that are provided in specific betting areas on tables so that a dealer can see that a player has made a bet on a particular outcome and/or during a betting round. A game or event may include multiple betting rounds, where a player is able to make a particular bet in conjunction with a phase and/or a round in the game or event. The betting may result in a win, loss, push, or other outcome, and the player may be paid chips equivalent to an amount of winnings.

[0058] The ability to track bets in real or near-real time may be of commercial and financial importance to a gaming facility. Inaccurate tracking of bets may lead to increased management overhead and/or an inability to accurate track betting, which may, for example, lead to missed opportunities to enhance player experience, or missed malicious behavior trends. For example, analyzing betting patterns may indicate that some players are "gaming the system" by placing suspicious bets (e.g., due to card counting, hole carding), or may indicate particularly profitable bets for the gaming facility (e.g., Blackjack insurance bets). The bet tracking information may be utilized in conjunction with other types of backend systems, such as a hand counting system, a security management system, a player compensation system (e.g., for calculating when complimentary items / bonuses are provided), etc. Bet recognition may also be used in gaming training systems, where players can be informed that their betting was not efficient or suboptimal based on computer-based simulation and calculation of odds (e.g., for Texas Hold-em poker, efficient betting may be determined based on mathematical odds and table positioning, especially for structured betting games and/or pot-limit and limit games, and may also be influenced by the presence of rule modifications).

[0059] In some embodiments, bet tracking information is collected using machine-vision capable sensors that may be present on a gaming table or surface, or other type of gaming machine. These machine-vision capable sensors monitor betting areas to determine the types of chips placed in them, and estimate the value of bets, tracking betting as betting progresses from round to round and from game to game. As many gaming facilities have invested significantly into their existing chips, tables, technologies and/or layouts, some embodiments described herein are designed for flexibility and interoperation with a variety of existing technologies and architectures. Machine vision is not limited to imaging in the visual spectrum, but may also include, in various embodiments, imaging in other frequency spectra, RADAR, SONAR, etc. Machine vision may include image processing techniques, such as filtering, registration, stitching, thresholding, pixel counting, segmentation, edge detection, optical character recognition, among others.

[0060] Accordingly, a bet tracking system may benefit from being able to be retrofit into existing tables and/or layouts, and interface with other table and/or gaming facility management systems (e.g., to communicate information regarding betting activities). Machine-learning techniques (e.g., random forests) may be utilized and refined such that visual features representative of different chip values are readily identified, despite variations between different facilities, lighting conditions and chip types. For example, such a system may not necessarily need to have hard-coded reference libraries of what chips should look like for each value, and instead, may be flexibly provisioned during the calibration process to build a reference library using real-world images of chips to train a base set of features. Accordingly, in some embodiments, the system may be utilized without *a priori* knowledge of the markers present on the various betting markers, such as chips. This may be useful where a system may need to account for introduced variations in chip design, which, for security reasons, are not distributed ahead of introduction.

[0061] A potential challenge with tracking bets is that there are a diversity of betting markers, objects on a gaming surface, lighting conditions that may lead to complexities in relation to accurately determining what bet markers are present, and further, what value should be attributed to a bet. Bets may be placed off-center by players, chips may not be uniformly stacked, chips may be obscuring one another, players may obscure bets using their hands, players may be deliberately modifying their bets (e.g., surreptitiously adding to a bet after cards have been dealt

to obtain a higher payout), etc. Bet recognition also is preferably conducted with minimal disruption to the operations of the gaming facility or player experience.

[0062] There may also be limitations on the amount of available computing resources, and given that many gaming tables operate with a high volume of games per hour, there is limited time available for processing (especially where bet data is being tracked in real or near-real time). Gaming facilities may have computational resources available at different locations, and these locations may need to communicate with one another over limited bandwidth connections. For example, there may be some computing components provided at or near a gaming table such that pre-processing may be conducted on sensory data, so that a compressed and/or extracted set of data may be passed to a backend for more computationally intensive analysis. In some embodiments, the backend may revert computed information back to the computing components provided at or near a gaming table so that a dealer or a pit-boss, or other gaming employee may use an interface to monitor betting activities (e.g., to determine "comp" amounts, track suspicious betting patterns, identify miscalculated payouts).

[0063] Bet recognitions systems may utilize sensors positioned at a variety of different locations to obtain information. For example, systems may utilize overhead cameras, such as existing security cameras. A challenge with overhead camera systems is that the presence of shadows, skewed image angles, obstructions, have rendered some embodiments particularly complicated from a computational perspective, as issues relating to data quality and the amount of visible information may lead to unacceptably low accuracy and/or confidence in computationally estimated bet counts.

[0064] **FIG. 1A** illustrates a block diagram of a system for monitoring betting activities at gaming tables according to some embodiments. The system may be configured such that sensors and/or imaging components are utilized to track betting activities, generating sensory data that is sent to a backend for processing. The betting activities may be provided in the form of chips being placed in betting areas, and the sensors and/or imaging components may include machine-vision sensors adapted for capturing images of the betting areas.

[0065] As depicted, the system includes bet recognition devices **30** (1 to N) integrated with gaming tables (1 to N). The bet recognition devices **30** may include various sensors and imaging components, among other physical hardware devices.

[0066] Each bet recognition device **30** has an imaging component for capturing image data for the gaming table surface. The gaming table surface has defined betting areas, and the imaging component captures image data for the betting areas. A transceiver transmits the captured image data over a network and receives calibration data for calibrating the bet recognition device **30** for the betting areas. Bet recognition device **30** may also include a sensor component and a scale component, in some embodiments. The image data may, for example, focus on a particular region of interest or regions of interest that are within the field of view of the sensor component.

[0067] In some embodiments, the bet recognition devices **30** are hardware electronic circuitry that are coupled directly in or indirectly to a gaming surface. In some embodiments, the bet recognition device **30** is integrated into the gaming surface. The bet recognition device **30** may be provided as a retrofit for existing gaming surfaces (e.g., screwed in, provided as part of a chip tray).

[0068] The bet recognition devices **30** may further include illuminating components or other peripheral components utilized to increase the accuracy of the bet recognition. For example, an illuminating bar may be provided that provides direct illumination to chip stacks such that the imaging component is more able to obtain consistent imagery, which may aid in processing and/or pre-processing of image data. Another peripheral component may include the use of pressure sensitive sensors at the betting area to denote when there are chips present in the betting area, and in some embodiments, the weight of the chips (e.g., which can be used to infer how many chips, which can be cross-checked against the image data).

[0069] The bet recognition device **30** may have one or more processors and computational capabilities directly built into the bet recognition device **30**. In some embodiments, these computational capabilities may be limited in nature, but may provide for image pre-processing features that may be used to improve the efficiency (e.g., file-size, relevancy, redundancy, load balancing) of images ultimately provided to a backend for downstream processing. The bet recognition device **30** may also include some storage features for maintaining past data and records. Some implementations provide for a very limited window of processing time (e.g., fast betting rounds or game resolution), and the pre-processing aids in speeding up computation so that it may be conducted in a feasible manner in view of resource constraints.

[0070] In some embodiments, the bet recognition device **30** contains multiple physical processors, each of the physical processors associated with a corresponding sensor and adapted

to track a particular bet area. In such an embodiment, the system has increased redundancy as the failure of a processor may not result in a failure of the entirety of bet recognition capabilities, and the system may also provide for load balancing across each of the physical processors, improving the efficiency of computations. Each sensor may be tracked, for example, using an individual processing thread.

[0071] The system includes a game monitoring server **20** with a processor coupled to a data store **70**. In some embodiments, the game monitoring server **20** resides on, near or proximate the gaming surface or gaming table. For example, the game monitoring server **20** may include a computing system that is provided as part of a dealer terminal, a computer that is physically present at a gaming station, etc.

[0072] The game monitoring server **20** processes the image data received from the bet recognition devices **30** over the network to detect, for each betting area, a number of chips and a final bet value for the chips. The game monitoring server **20** may also process other data including sensor data and scale data, as described herein.

[0073] The game monitoring server **20** is configured to aggregate game activity data received from bet recognition devices **30** and transmit commands and data to bet recognition devices **30** and other connected devices. The game monitoring server **20** processes and transforms the game activity data from various bet recognition devices **30** to compute bet data and to conduct other statistical analysis.

[0074] The game monitoring server **20** may connect to the bet recognition devices **30** via bet recognition utility **40**. The bet recognition utility **40** aggregates image data received from multiple bet recognition devices **30** for provision to the game monitoring server **20** in a tiered manner. In some example embodiments, game monitoring server **20** may connect to multiple bet recognition utilities **40**.

[0075] Each bet recognition device **30** may be linked to a particular gaming table and monitor game activities at the gaming table. A gaming table may be retrofit to integrate with bet recognition device **30**. Bet recognition device **30** includes an imaging component as described herein. In some embodiments, bet recognition device **30** may also include sensors or scales to detect chips.

[0076] Bet recognition utility device **40** connects bet recognition devices **30** to the game monitoring server device **20**. Bet recognition utility **40** may act as a hub and aggregate, pre-process, normalize or otherwise transform game activity data, including image data of the gaming tables. In some embodiments, bet recognition utility **40** may relay data. Bet recognition utility **40** may be linked to a group of gaming tables, or a location, for example.

[0077] Bet recognition utility device **40**, for example, may be a backend server cluster or data center that has a larger set of available computing resources relative to the game monitoring server **20**. The bet recognition utility device **40** may be configured to provide image data in the form of extracted and/or compressed information, and may also receive accompanying metadata tracked by the bet recognition device **30**, such as timestamps, clock synchronization information, dealer ID, player ID, image characteristics (e.g., aperture, shutter speed, white balance), tracked lighting conditions, reference illumination settings, among others.

[0078] This accompanying metadata, for example, may be used to provide characteristics that are utilized in a feedback loop when bet outcomes are tracked. For example, the type of image characteristics or reference illumination characteristics of the bet recognition utility device **40** may be dynamically modified responsive to the confidence and/or accuracy of image processing performed by the bet recognition utility device **40**. In some embodiments, the bet recognition utility device **40** extracts from the image data a three-dimensional representation of the betting and maybe used to track not only betting values but also chip positioning, orientation, among others. This information may, for example, be used to track patterns of betting and relate the patterns to hand outcomes, the provisioning of complimentary items, player profile characteristics, etc.

[0079] The system may also include a front end interface **60** to transmit calculated bet data, and receive game event requests from different interfaces. As shown in **FIG. 2**, front end interface **60** may reside on different types of devices. Front end interface **80** may provide different reporting services and graphical renderings of bet data for client devices. Graphical renderings of bet data may be used, for example, by various parties and/or stakeholders in analyzing betting trends. Gaming facilities may track the aggregate amounts of bets by account, demographic, dealer, game type, bet type, etc. Dealers may utilize betting information on a suitable interface to verify and/or validate betting that is occurring at a table, pit bosses may use the betting information to more accurately determine when complementary items should be dispensed and provided, etc.

[0080] Front end interface **60** may provide an interface to game monitoring server **20** for end user devices and third-party systems **50**. Front end interface **60** may generate, assemble and transmit interface screens as web-based configuration for cross-platform access. An example implementation may utilize Socket.io for fast data access and real-time data updates.

[0081] Front end interface **60** may assemble and generate a computing interface (e.g., a web-based interface). A user can use the computing interface to subscribe for real time game event data feeds for particular gaming tables, via front end interface **60**. The interface may include a first webpage as a main dashboard where a user can see all the live gaming tables and bet data in real time, or near real time. For example, the main dashboard page may display bet data, hand count data, player count data, dealer information, surveillance video image, and so on. Bet data may include, for example, total average and hourly average bets per hand, player or dealer, per hour bet data for each gaming table in real time, and so on. The display may be updated in real-time.

[0082] The interface may include a management page where management users can perform management related functions. For example, the interface may enable management users to assign dealers to inactive gaming tables or close live gaming tables. An on and off state of a gaming table may send a notification to all instances of the interface. If a user is on the monitor management page when a new gaming table is opened, the user may see the live gaming table updated on their display screen in real-time. The management page may also shows surveillance images of each gaming table, and other collected data. The surveillance images may be used or triggered upon detection of particular patterns of bet data at a gaming table, for example.

[0083] Front end interface **60** may include a historical data webpage, which may display historical bet data of a selected gaming table. It may allow the user to browse the historical bet data by providing a date range selecting control. The bet data may be organized hourly, daily, monthly, and so on depending on the range the user chooses. The bet data along with the hand data and a theoretical earning coefficient may be used to estimate the net earnings of the gaming table over the selected date period.

[0084] A server and client model may be structured based on receiving and manipulating various sorts of game event data, such as hand count data, betting data, player data, dealer data, and so on. The interface may be expanded to process other types of game data such as average bets per hands on a table. Bet data can be displayed on the monitor or management page in an

additional graph, for example. The date range selection tool may be used for analyzing the added data along with the bet data. Similarly, the main dashboard may show real-time statistics of both the bet data and the additional game data.

[0085] In some embodiments, the bet recognition utility device **40** may receive activation / deactivation signals obtained from various external devices, such as an external shoe, a hand counting system, a player account registration system, a pit boss / employee manual triggering system, etc. These external devices may be adapted to transmit signals representative of when a betting event has occurred or has terminated. For example, a specially configured dealer shoe may be operated to transmit signals when the dealer shoe is shaken, repositioned, activated, etc., or a hand counting system may be interoperating with the bet recognition utility device **40** to indicate that a new round of betting has occurred, etc. In some embodiments, betting may be triggered based on the particular game being played in view of pre-defined logical rules establishing when betting rounds occur, when optional betting is possible (e.g., side-bets, insurance bets, progressive bets), etc.

[0086] The system **10** may also integrate with one or more third party systems **50** for data exchange. For example, a third party system **50** may collect dealer monitoring data which may be integrated with the bet data generated by game monitoring server device **20**. As another example, a third party system **50** may collect player monitoring data which may be integrated with the bet data generated by game monitoring server device **20**.

[0087] **FIG. 1B** is an example block schematic **100B** illustrative of some components of a bet recognition system **200**, according to some embodiments. The components shown are for example only and may reside in different platforms and/or devices. The system **200** may include, for example, an imaging component **202** including one or more sensors to detect and/or obtain image data representative of betting areas. The imaging components **202** may be, for example, cameras, sensors, and may collect image data in the form of video, pictures, histogram data, in various formats. The image data may have particular characteristics tracked in the form of associated metadata, such as shutter speeds, camera positions, imaging spectra, reference illumination characteristics, etc. In some embodiments, the imaging components may provide an initial pre-processing to perform preliminary feature recognition, optical character recognition, etc. For example, the gaming surface may have visual indicators which may be tracked as reference markers by the imaging components (e.g., optical position markers indicative of betting areas where bets may be placed).

[0088] An image processing engine **204** may be provided that is configured to receive the images and to extract features from the images. In some embodiments, the image processing engine **204** segments and/or pre-processes the raw image data to remove noise, artifacts, and/or background / foreground imagery. For example, the image processing engine **204** may be configured to visually identify the pixels and/or regions of interest (e.g., by using a combination of depth data and similarity / size information) regarding the chips. Specific stacks of chips may be identified, along with their constituent chips. The chips may have "bounding boxes" drawn over them, indicative of the pixels to be used for analysis. Similarly, in some embodiments, "bounding boxes" are drawn over entire stacks of chips. The image processing engine **204** may extract features from the bounding boxes and, for example, create a compressed transform representative of a subset of the image information. For example, in some embodiments, various vertical, horizontal, or diagonal lines of information may be drawn through a determined stack of chips, and samples may be obtained through tracking the image pixels proximate to and/or around a determined centroid for each of the chips.

[0089] In some embodiments, to account for variations in markings (e.g., vertical stripes), the pixels (e.g., horizontal pixels) estimated to comprise a particular chip are blurred and/or have other effects performed on them prior to extraction such that the centroid and its surrounding pixels are representative of the chip as a whole.

[0090] The image processing engine **204** may also extract out a particular height of the chips, and this information may be utilized to determine the general size and/or makeup of the stack of chips. For example, knowledge of the chip stack, distance, and height of specific chips may permit for the segmentation of pixel information on a per-chip basis.

[0091] The image recognizer engine **206** may obtain the extracted and compressed information from the image processing engine **204**, applying recognition techniques to determine the actual chip value for each chip in the relevant region of interest. As the image recognizer engine **206** receives a set of features, the image recognizer engine **206** may be configured to utilize a classifier to determine how well the feature set corresponds to various reference templates. In some embodiments, the classifier provides both an estimated value and a confidence score (e.g., a margin of error indicative of the level of distinction between potential chip value candidates). Where the chip value cannot be reliably ascertained through the reference templates, a notification may be provided to either request re-imaging with varied characteristics, or to generate an error value. For example, features may be poorly captured due

to changes in ambient lighting and/or environmental shadows, and the notification from the classifier may control a reference lighting source to activate and/or modify illumination to potentially obtain a more useful set of image features.

[0092] In some embodiments, the image recognizer engine **206** may dynamically provision computing resources to be used for recognition. For example, if the image recognizer engine **206** identifies that a larger amount of processing will be required in view of a large volume of poor quality image data, it may pre-emptively request additional processing resources in view of a requirement to complete processing within a particular timeframe. Conversely, in some embodiments, where image data is of sufficiently high quality to quickly and accurately conclude that a chip is a particular type of chip, processing resources may be freed up.

[0093] A rules engine subsystem **208** may be provided in relation to classification of chip image data / features to chip values. The rules engine subsystem **208** may, for example, include tracked linkages and associations that are used by the classifier to determine a relationship between a particular reference feature set. In some embodiments, the rules engine subsystem **208** includes weighted rules whose weights dynamically vary in view of updated reference feature sets or accuracy feedback information (e.g., indicated false positives, false negatives, true positives, true negatives), among others. The rules engine subsystem **208** may also include logical processing rules that control operation of various characteristics of the classifier, the reference illumination, processing characteristics, etc.

[0094] A game monitoring engine **210** may obtain the tracked chip / bet values for each bet, for example, from a plurality of imaging components **202**, processing engines **204** and/or recognizer engines **206**, and maintain an inventory of betting data, which may be stored in data storage **250**. The game monitoring engine **210** may be adapted to provide real or near-real-time feedback, and also to perform various analyses (e.g., overnight processing). The game monitoring engine **210** may identify patterns from combining bet tracking data with other data, such as player profile information, demographics, hand counting information, dealer tracking information, etc.

[0095] An administrative interface subsystem **212** may be provided for administrative users to control how the system operates and/or to request particular analyses and/or reports. A user interface subsystem **214** may provide, for example, various graphical interfaces for understanding and/or parsing the tracked bet recognition data. The graphical interfaces may, for example, be

configured to generate notifications based on tracked discrepancies, etc. The various components may interoperate through a network **270**.

[0096] In some example embodiments, game monitoring server **20** may connect directly to bet recognition devices **30**. **FIG. 2** illustrates a block diagram **200** of another system for monitoring game activities at gaming tables according to some embodiments. System may include bet recognition device **30** at gaming table with defined bet areas **34** on the gaming table surface. In this example, bet recognition device **30** directly connects to game monitoring server **20** to provide image data for the gaming table surface and the bet areas **34**.

[0097] **FIG. 3** illustrates a block diagram **300** of a further system for monitoring game activities at gaming tables according to some embodiments involving betting data and hand count data. Card game activities may generally include dealing card hands, betting, playing card hands, and so on. Each player, including the dealer and customers, may be dealt a card hand. For a card game, each active player may be associated with a card hand. The card hand may be dynamic and change over rounds of the card game through various plays. A complete card game may result in a final card hand for remaining active players, final bets, determination of winning card hands amongst those active players' hands, and determination of a winning prize based on winning card hands and the final bets. At different rounds or stages of the game different players make bets by placing chips in bet regions on the gaming table surface.

[0098] Bet recognition device **30** and hand count device **32** may be integrated at each gaming table for capturing image data for bets and counting the number of card hands played at the particular gaming table. Hand count device **32** is another example of a game monitoring device. A player may have multiple card hands over multiple games, with different bets associated with hands. Hand count device **32** may count the number of hands played at a gaming table, where the hands may be played by various players. Bet recognition device **30** may collect image data for server **20** to calculate bet data for different hands and players.

[0099] Hand count device **32** may determine a player hand count may be over a time period. Bet recognition device **30** may determine bet data over a time period, using timestamps, for example. Server **20** may correlate hand count and bet data using timestamps or time periods, for example. The information may be stored on data store **70**, and presented on front enter interface **60**.

[00100] Bet recognition device **30** may associate bet data with a particular gaming table, dealer, customers, geographic location, subset of gaming tables, game type, and so on. Similarly, hand count device **32** may associate hand count data with a particular gaming table, dealer, customers, geographic location, subset of gaming tables, game type, and so on. For example, bet data may be associated with a timestamp and gaming table identifier to link data structures for further data analysis, processing and transformation.

[00101] Metadata is collected alongside image data and may be associated (e.g., using pointers, labels, metadata tags) with the image data to indicate additional information, such as checksums (e.g., for redundancy and immutability), timestamps, player information, hand count information, bet round information, lighting conditions, reference lighting characteristics, confidence score associated with image data, sensors in use, processor in use, etc.

[00102] Image data, along with other metadata may be encapsulated in the form of information channels that may be use for transmission and/or otherwise encoded. In some embodiments, 10 or more channels of information are provided by the bet recognition device **30**, and the channels may include, for example, image data taken with different color balances and parameters, image data from different sensors, metadata, etc.

[00103] Each bet recognition device **30** may transmit image data or other bet data to bet recognition utility **42** for provision to game monitoring server **20**. Each hand count device **32** may transmit hand count data from a sensor array to hand count utility **42** for provision to game monitoring server **20**. Further details on hand count device **32** and game monitoring server **20** for calculating hand count data is described in U.S. Provisional Application No. 62/064,675 filed October 16, 2014.

[00104] Hand count device **32** may include sensors, such as for example laser sensors with optical emitters and receivers. Laser sensors, instead of other types such as ambient light sensors, may be advantageous to reduce the effect of lighting in the environment, to not require special table top felt material, to waterproof the device, and so on. Ambient light sensors may not work well if a part of the table is not well lit, as those types of sensors are looking for darkness for object detection. Hand count device **32** may use optical receiver and emitter sensors that look for light for object detection. Additional types of sensors include radio frequency and optics. The sensors may be organized to form a sensor array. Hand count device **32** may further include an infrared receiver and infrared emitter or transmitter for electronic data exchange. The sensors

are particularly configured and positioned relative to the play area and bet area on the gaming table. For example, a sensor array may be positioned proximate to the card play area and bet area. The device may be configured to provide a particular distance between sensor and card play area or bet area, such as a one centimeter distance, for example.

[00105] Bet recognition device **30** may similarly retrieve image data captured by imaging component. Hand count device **32** may receive power and retrieve data off of sensors used for monitoring game activities. Both hand count device **32** and bet recognition device **30** generate game activity data (which may also be referred to herein as game event data) for provision to game monitoring server **20**. Game activity data may include hand count data events, such as hand start event data and hand stop event data. Hand start event data indicates the start of a new hand. Hand stop event data indicates the end of a hand. Together with timestamps these values may be used to compute hand duration and other data values. Bet data may also be linked by timestamps. The sensors of hand count device **32** may be positioned on the gaming table to detect card hand activities and trigger hand start events and hand stop events. The sensors may deliver real-time data regarding card play activity, including hand start event data and hand stop event data. The imaging components may also deliver real-time image data regarding bet activities. The imaging component of bet recognition device may be mounted or integrated into gaming table to capture real-time image data for bet areas on the gaming table surface.

In some embodiments, the clocks of the bet recognition device **30**, the hand count device **32**, game monitoring server **20** are synchronized together to ensure that data is readily interpretable regardless of source.

[00106] Bet recognition device **30** may be configured with particular trigger events, such as detection of chips or objects in defined bet areas on the gaming table by sensors. The trigger events may trigger imaging component to capture image data for calculating bet values for the chips. A timing or threshold value may be set off to trigger transmission of game event data used to calculate bet data and count card hands. An example trigger may be sensor activation for a threshold value, for example two, three or four seconds. Another example trigger may be sensor deactivation for a threshold value.

[00107] Game activity data may include bet data, player count data and hand count data, which may be valuable for casinos for security, management, and data analytics. For example, a casino

may determine a link between a game and a dealer, and also a dealer and a customer, through the bet data, the hand count data and the player count data. A casino may provide real-time compensation to players using the bet data, hand count, and player count data. Accordingly, the systems, devices and methods in accordance with embodiments described herein may provide various levels of granularity and specificity for game activity data, using the bet data, hand count data, player count data, and other generated game activity data values. There may further be third party player tracking and/or dealer tracking data **50** that may be utilized in relation to performing analysis and reporting.

[00108] A gaming table includes one or more bet areas. **FIGS. 4A-4C** illustrates a schematic diagram of bet areas **34** monitored by a bet recognition device **30** according to some embodiments.

[00109] As illustrated in **FIGS. 4A-4C**, a challenge with tracking betting and chips is the ability to obtain sufficient quality and resolution to accurately track bets. **FIG. 4A** is an overhead or elevational top view **400A**, according to some embodiments. **FIG. 4B** is a perspective view **400B**, according to some embodiments. **FIG. 4C** is an overhead or elevational top view **400C** in relation to a camera system **30**, according to some embodiments. Bets **402** may be placed in a betting area **34** on a gaming table, and for example, betting areas may be demarcated through the use of machine-vision interpretable boundaries, etc. The bets may include various chips, and the chips may have different values attributed to the chips. The chips may be placed in one or more stacks within the field of view of the camera system **30**.

[00110] These boundaries, for example, may appear to be a single visual ring to a player, but in some embodiments, layers of different boundaries (e.g., as different rings) may be utilized to more granularly indicate slight differences in positioning of chips. For example, boundaries that are only visible in the infrared or ultraviolet lighting may be used, and these may be tracked by machine-vision sensors to demarcate where the betting area begins, ends, different parts of a betting area, etc. For example, such granular boundaries may be helpful where small differences in depth, positioning, etc. may impact the accuracy of such a system. Visual and/or other types of optical markers may be used to serve as reference areas for depth calculations

[00111] While some other systems have utilized overhead cameras positioned over a table or based on tracking images captured from overhead security cameras, these systems have had difficulties obtaining sufficiently high quality images of chips placed in betting areas to be able to

accurately and responsively track bet counting. For example, using an overhead camera may lead to an inconsistent number of pixels being used to track each chip, the number of available pixels being limited due to the obstruction caused by chips being placed on one another (e.g., an overhead camera directly above a stack of chips may not be able to adequately identify chips underneath the top chip of a stack, or if it is placed at an overhead some distance away, the system may not have a good view of the individual chips within the stack as there may either be obstructions or the specific angle of the chips may cause undesirable shadowing effects. For example, depending on a camera's ability to obtain images, chips deep in a stack of chips may all appear to be black as the chips in the stack end up casting shadows on one another. Perspective views of chips may computationally difficult to analyze in view of the required transformations to obtain a representative set of pixels.

[00112] Similarly, it may be difficult to account for variations of ambient and environmental lighting that may be illuminating the chips themselves. Where differences in illumination intensities are utilized to track chip values and distances, such variations may reduce the accuracy of readings or provide false positive / false negative readings.

[00113] In some embodiments, imaging components (e.g., cameras) are placed and positioned to have a substantially horizontal sensor angle when viewing the chips, a depiction of which is provided at **FIG. 4B**. Substantially horizontal may mean substantially parallel to a plane of the gaming surface.

[00114] The imaging components may be adapted such that the imaging component is directed towards the betting areas from or near the perspective of a dealer. Such a configuration may be helpful in ensuring that the chips are less obstructed, and provide a sufficient view of the sidewalls of the chips. An "offset angle" may be provided where the imaging components, while "looking" substantially parallel at the sidewalls of the chips, due to the stacked nature of chips, may aid in obtaining as many pixels as possible.

[00115] As described, the imaging component angle may be important to ensure that as many pixels of information can be extracted from a machine-vision image that are representative of chips. The imaging component itself may also require to be off-set from the gaming surface (e.g., at a particular altitude or height) such that the sensing is not blocked by the presence of objects on the gaming surface, such as playing cards, dice, markers, etc. For example, a card may be curled at a corner, and a sensor placed directly horizontal and in contact with the gaming surface

may end up being obstructed by the cards (and thus unable to read the value of the chips). The horizontal angle, for example, may be an angle between -5 to 5 degrees, and the altitude may be between 0.2 cm to 1.0 cm. While the image obtained may be direct for some chips, there is nonetheless some angle for chips that are at the top or the bottom of the stack.

[00116] In some embodiments, the imaging component may be utilized in combination with an illumination strip, the illumination strip (e.g., lights, infrared lights, ultraviolet lights) providing a "reference illumination" against the sidewall of the chips.

[00117] For example, the illumination strip may be placed above or below the imaging component and may provide illumination in all or a portion of the field of view of the imaging component. The illumination provided may be static (e.g., a regular light) or controlled (e.g., a controllable light). The illumination characteristics may be modified (e.g., filters applied, the amount of total light controlled, the spectral makeup of the light may change, etc.). The illumination characteristics may be used in various ways, for example, to ensure that at a minimum number of pixels are able to be captured per chip, to ensure that there is constant reference illumination despite changes in ambient lighting, etc.

[00118] In some embodiments, illumination characteristics are modified in response to requests from the system. For example, the system may determine that there indeed are chips providing in a particular area, but the system is experiencing difficulty in assessing the value of the chips (e.g., due to environmental, ambient illumination, distortions.

[00119] In some embodiments, the imaging component and/or the illumination is provided on a physical track or pivot and is able to modify viewing angles and/or positions (or both) in response to poor image recognition. For example, at some angles, chips may be covered by shadows (especially the bottom chips of a stack) and due to the shadowing, may appear to be indistinguishable from other chips or erroneously recognized. The classifier may identify a low level of confidence in the recognition and in response, generate a control signal to move the camera and/or pivot the camera and/or other sensors, such as depth sensors, etc.

[00120] A control system may note that the recognition device is having difficulty (e.g., by an increase in error rate, failing to meeting a pre-defined threshold of pixels required to make an accurate determination) and issue a command control to the illumination device to control the

illumination device to more actively "light up" the chips so that a better picture may be taken for conducting image recognition.

[00121] Similarly, bet recognition devices may be designed to operate in environments where the amount of environmental and ambient lighting varies quite frequently. Light may be provided from natural sources (e.g., windows), or from artificial sources. Ambient lighting may occur from artificial sources that are incident to the bet recognition device, such as the lights provided on other machines, room lighting, etc. In some embodiments, a gaming facility may purposefully modify the lighting conditions to impress upon the players a particular ambience or theme. Individuals at the facility may be smoking, casting shadows, etc.

[00122] These variations may significantly impact the ability of the system to perform bet recognition. A commercial consideration as to how the system functions is the ability to operate the system in a variety of different environments having different lighting conditions. For example, a bet recognition system may require some level of portability as the system may be moved around a gaming facility over its lifetime, or sold and/or moved between different gaming facilities.

[00123] In some embodiments, the aspect ratio associated with the imaging component may be a factor for consideration. For example, if the imaging component was a 1080p camera, it means it has more pixels horizontally than vertically, so the extra resolution in the width is more valuable in measuring the thickness of the chip. Rotating from a landscape orientation to a portrait orientation would allow for more resolution for distinguishing chips from one another within a stack, potentially offering more detail to for downstream processing.

[00124] In some embodiments, an illumination strip provides the reference illumination, and the reference illumination may be provided in a substantially horizontal view relative to the sidewalls of the chips. The reference illumination may, relative to overhead camera systems, provide more direct and relatively unobstructed illumination to the chip sidewalls, making any machine-vision interpretable markings more visible and easy to distinguish. As an example in the context of machine vision, particular colors may be difficult to distinguish from one another (e.g., red from pink), and similarly, striped markings may also be difficult to process as poor lighting may impact the ability to determine how thick a line is, etc. This problem may be particularly exacerbated if the machine-vision is not operating in the same range wavelengths as human vision, for example, if the machine vision operates in infrared, ultraviolet ranges, monochromatic ranges, etc.

[00125] The reference illumination may be provided in proximate to or substantially at the same location as the imaging components. For example, the reference illumination may be provided in the form of an illumination strip running across a sensor housing. In some embodiments, the reference illumination is provided in the form of spaced-apart light sources.

[00126] Accordingly, in some embodiments, the reference illumination in accordance with control signals such that the reference illumination characteristics (intensity, spread, spectral makeup, etc.) may be modified and monitored to dynamically adjust and/or control for variations from light provided from other sources For example, control signals may be provided, which when processed by the illumination strip, the illumination strip changes an intensity of the reference illumination based at least on ambient lighting conditions. The control signals may be adapted to implement a feedback loop wherein the reference illumination on the one or more chips is substantially constant despite changes to the ambient lighting conditions.

[00127] In some embodiments, rather than, or in combination with changing the reference illumination to provide a constant lighting condition, the reference illumination is adapted to monitor a confidence level associated with the bet recognition processing from machine-vision images that are provided to a backend system. For example, if the backend image processing system indicates that there are significant accuracy and/or confidence issues, the backend image processing system may be configured to generate a control signal requesting modifications to the reference illumination relative to the chips themselves. Outcomes may be monitored, for example, by using a feedback loop, and controlled such that an optimal amount of reference lighting is provided. In some embodiments, the reference illumination is not constant, but is rather adjusted to ensure that a sufficiently high level of confidence is obtained during image processing. In some embodiments, reference illumination may be provided in a strobe fashion and/or otherwise intermittently used when image processing capabilities are impacted (e.g., a transient shadow passes by, the chips are momentarily obstructed by the hand of a player or the dealer, etc.).

[00128] The reference illumination, to save energy, may, in some embodiments, be controlled such that it can be turned on whenever additional illumination is required.

[00129] Embodiments described herein provide a game monitoring server **20** configured to calculate a red green blue (RGB) Depth Bounding Area for a gaming table to calibrate the corresponding bet recognition device **30**.

[00130] Game monitoring server **20** and bet recognition device **30** calibrates each bet area to ensure that only the chips in the bet area are counted, and not chips in other areas of the gaming table that are not in play. The bet area may be defined in response to input received at front end interface **60** providing a graphical display of the gaming table surface and using an input device (e.g. a keyboard and mouse) to define a region. As another illustrative example, the bet area may also be defined by positioning chips in the bet area and nothing else on the gaming table.

[00131] Game monitoring server **20** and bet recognition device **30** may automatically implement bet area calibration by scanning the gaming table and detecting any chips on the gaming table surface. If the chips on the gaming table are directly inside the bet area then game monitoring server **20** will automatically record xyz coordinate values for the detected chips.

[00132] The game monitoring server **20** may be configured for performing various steps of calibration, and the calibration may include developing an array of reference templates in relation to the particular set up of a gaming surface or gaming table. For example, the reference templates may include what chips "look like" at a particular table in view of usual gameplay settings, etc. Further, the reference templates may track lighting conditions across the span of a day, a season, in view of upcoming events, nearby light sources (e.g., slot machines), etc. New templates may be provided, for example, when new chips or variations of chip types are being introduced into circulation at a particular gaming facility. In some embodiments, such introduction of new chips may require a machine-learning training phase to be conducted to build a reference library.

[00133] The calibration may be conducted, for example, on an empty table to determine where the betting areas should be, where any demarcations exist, etc. The calibration may be used to "true up" color settings, lighting conditions, distances, etc. For example, the reference templates may be indicative of how many pixels are generally in a chip in a first betting area, based on their position on a stack of chips, etc. The calibration may also track the particular height of chip stacks based on how many chips are in the stacks and what kind of chips are in the stack. These reference values may be stored for future use during bet recognition, and may be compressed such that only a subset of features are stored for reference. The subset of features stored, for example, may be utilized in a pattern recognition and/or downstream machine-learning approach where relationships are dynamically identified between particular features and recognized bets.

[00134] The calibration may be conducted with reference games and betting, and tracked against manual and/or semi-manual review to determine accuracy and features for extraction, and characteristics associated with the bet recognition may be modified over time. For example, the processing / pre-processing steps may be modified to change definitions of bet areas, bounding boxes, what image features are considered background or foreground, how lighting needs to be compensated for in view of changing lighting conditions, transient shadowing, etc.

[00135] Embodiments described herein provide a game monitoring server **20** configured to monitor betting activities by calculating RGB and Depth Data for chips detected within bet areas of the gaming table.

[00136] The game monitoring server **20** may be configured to generate an electronic representation of the gaming table surface. The game monitoring server **20** is configured to process the captured chip data images by segmenting the background chips and other data from the gaming table images relative to the distance from camera component of the bet recognition device **30**, or relative to the position on the gaming table. The bet recognition device **30** may only capture and transmit portions of the image data relating to the chip stack itself to the game monitoring server **20** via bet recognition utility **40**. In accordance with some embodiments the game monitoring server **20** or bet recognition utility **40** receive image data for the gaming table surface and perform processing operations to reduce the image data to portions of the image data relating to the chip stack itself. The game monitoring server **20** implements image processing to transform the image data in order to detect the number of chips in the betting area and ultimately the final value of the chips.

[00137] In some embodiments, the electronic representation of the gaming table surface is used as a streamlined approach to extracting information relevant to the bet recognition. For example, the gaming table surface may be represented in two-or three dimensional space and used for coordinate positioning. There may be defined bet areas that are provided based on position, etc. and in some embodiments, the actual bet areas may include further markings that may or may not be visible to human players that are used for machine vision boundary demarcation and/or depth calculations. For example, there may be areas indicated to indicate depth (e.g., if a particular boundary is covered, the boundary is known to be at position (x, y), and therefore a chip stack is at least around or covering position (x, y).

[00138] The game monitoring server **20** may utilize the electronic representation in generating a streamlined set of compressed information that is used for downstream analysis, such as for bet recognition, confidence score tracking, machine learning, etc. For example, the electronic representation may be updated as chips are placed into betting areas and sensed by the sensors. The sensors may track various elements of information associated with the chips and modify the electronic representation to note that, with a particular confidence level, that a stack of chips has been placed, the stack of chips having a particular makeup and value of chips, etc. The game monitoring server 20 may then extract out only specific features and discard the other information in preparing a compressed set of information representative of the bets being placed on a gaming surface (e.g., only a simple set of depth coordinates, the estimated make-up of the chips in the stack, confidence values associated with how accurately the system considers its assessments to be, etc.).

[00139] Embodiments described herein provide a game monitoring server **20** configured to monitor betting activities by calculating depth data for chips detected within bet areas of the gaming table. Depth data can be captured with a variety of different processes using different imaging components. For example, an imaging component may include stereo cameras (e.g., RGB cameras) mounted in different positions on the gaming table to capture image data for the betting areas. An imaging component with stereo cameras may have two or more black/white or RGB cameras, for example. As another example, an imaging component may include a depth aware camera using Infrared (IR) and Time-Of-Flight (TOF). An imaging component with depth cameras may use IR TOF or IR projection of structured light or speckled pattern.

[00140] Depth data may be an important output in relation to machine-vision systems. For example, the distance from a chip may indicate how many available pixels would make up chips in an image of chips, etc. The number of available pixels may determine how a bounding box may be drawn (e.g., dimensions) around a chip, a stack of chips, etc., and in some embodiments, may be a factor in automatic determinations of confidence scores associated with machine-vision estimations of the values of the chips (e.g., if there are only 12 pixels available due to the stack being far away for a particular chip, and the pixels are impacted by poor lighting conditions and partial obstructions, the confidence score may be particularly low, especially if the chip has markers that are difficult to discern in poor lighting conditions).

[00141] Depth data may be generated based on, for example, tracking parallax effects (e.g., by moving a single sensor), stereoscopic effects (e.g., by comparing parallax in two different

cameras), pressure sensors in the betting areas, range finding radar (e.g., Doppler radar), UV light dispersion / brightness levels, distortion effects, etc.

[00142] Where sensors may be obstructed, depth data may be estimated from an aggregated set of captured images over a duration of time. For example, differences between each of the plurality of captured images may be compared to estimate the presence of the one or more chips despite the presence of the one or more obstructing objects that are partially or fully obstructing the one or more chips from being sensed by the one or more sensors.

[00143] The depth data may be determined in combination with a confidence score. For example, if a chip is particularly far away, there may be a limited number of pixels to analyze regarding the chip. The number of pixels available may be further reduced if lighting conditions are poor, the chips are obstructed, there are imaging artifacts, etc., and accordingly, a lower confidence score may be presented.

[00144] **FIGS. 5 to 7** illustrate example images taken from a bet recognition device mounted on a gaming table according to some embodiments. The image data for the images may include depth data taken from a table-mounted depth camera. The example images illustrate the table and bet area rendered in three-dimensions (3D). The image data defines stacks of chips in the bet areas in 3D defined using X, Y, and Z coordinate values. The game monitoring server **20** may represent a gaming table surface as a model of X, Y and Z coordinate values including betting areas.

[00145] As depicted in **FIG. 5**, the sensors may take images **500** of the gaming surface, including bet area **502/502'**, cards **508/508'**, stacks of chips **504/504'/506/506'**, etc. As noted in **FIG. 5**, there may be some chips in the foreground **504/504'**, some in the background **506/506'**, there may be other background images, etc. The images may be taken in human visible and/or non-human visible wavelength ranges. For example, the images may utilize infrared, ultraviolet, and accordingly, some wavelengths may be more prominent than others. Another image is depicted in **FIG. 6**, having bet area **602/602'**, cards **608/608'**, stacks of chips **604/604'/606/606'**, etc. As noted in **FIG. 6**, there may be some chips in the foreground **604/604'**, some in the background **606/606'**.

[00146] **FIG. 7** is a compressed representation **700**, wherein non-chip imagery has been filtered out, and the image primarily consists of images of stacks of chips **702**, **704**, and **706**. Filtering

techniques, for example, include the use of edge detection algorithms (e.g., difference of Gaussians). The representation **700** may be compressed such that chips are detected among other features, so that various regions of interest can be identified. In some embodiments, representation **700** is combined with depth data so that background and foreground chips may be distinguished from one another. For example, chips that may be within a betting area indicative of a bet may also have chips that are in the background (e.g., chips that the player has in the player's stacks that are not being used for betting). Depth data may be used to distinguish between those chips that are in the betting area as opposed to those chips that are out of the betting area.

[00147] In some embodiments, the imaging component may include a wide angle camera. The wide angle camera can used to capture image data for all bet areas game monitoring server **20** may implement correction operations on the image data to remove warping affects. **FIG. 8** illustrates an example schematic of a bet recognition device **30** with a wide angle camera.

[00148] In some embodiments, the imaging component may include three cameras **802**, **804** and **806** per gaming table. Three cameras may be mounted on a gaming table in a configuration in front of the dealer position on the gaming table. Each camera may be dedicated or responsible for two bet areas. When a hand has started (e.g., as per a detected hand start event) each camera may capture image data of their respective bet areas for transmission to game monitoring server **20**. The game monitoring server **20** stores the captured image data in a central data store **70**. When new image data is sent to the data store **70** it may be processed by game monitoring server **20** using the recognition process described herein. The processed image data may generate bet data including the number of chips in a bet area and the total value of chips in the bet area. Game monitoring server **20** stores calculated bet data at data store **70**. The bet data may be linked with timestamp which is also recorded at data store **70**. When all image data captured by the three cameras has been processed, image data for the hand played is recorded to the data store **70**. Game monitoring server **20** is operable to correlate the capture hand event data to the bet data to calculate bet values for particular hands.

[00149] The cameras of imaging component can be installed into the back bumper located between the dealer position and the gaming table. This installation process simplifies retrofitting existing gaming tables allowing the casino operator to replace the back bumper without having to impact the gaming table felt or surface.

[00150] **FIGS. 8** and **9** illustrate example images of a bet recognition device **30** mounted on a gaming table according to some embodiments. The illustrative example **900** shows three cameras as an imaging component of the bet recognition device **30**. The cameras are installed into the back bumper of the gaming table. Game monitoring server **20** can stitch together image data captured by different cameras to recreate a 3D model of the table surface using X, Y and Z coordinate values. In some example embodiments, the game monitoring server **20** may evaluate image data independently for each camera. Game monitoring server **20** uses the captured image data to generate a 3D model of the gaming table surface. Game monitoring server **20** processes the image data by isolating image data for all bet areas and cropping the image data for all bet areas for further processing. Game monitoring server **20** processes the image data for the bet area in order to find bet value for each bet area and total bet or chip amount for each bet area.

[00151] In some embodiments, the 3D model is utilized to generate a representation of where the system interprets and/or estimates the chips to be. The 3D model may be adapted to extrapolate position information based on known sizes and/or dimensions of chips, as the image data may often only include an incomplete set of information required to generate a 3D model. Multiple images may be stitched together to derive the 3D model.

[00152] **FIGS. 10** and **11** illustrate example images of a bet recognition devices **30** according to some embodiments. **FIG. 10** is an illustration **1000** of an example bet recognition device **30** including three cameras capturing different portions of the gaming table surface. **FIG. 11** is an illustration **1100** that illustrates another example bet recognition device **30** including a camera.

[00153] **FIG. 12** illustrates a schematic diagram of another example bet recognition device **30** according to some embodiments. The bet recognition device **30** may include a moving camera according to some embodiments. A linear bearing can be used alongside a stepper motor to move the camera from one side of the gaming table **1204** to the other. This allows for one camera system to capture image data of the gaming table surface from different angles (as denoted by the dashed lines). The number of image frames captured and the interval at which the image frames are captured can be defined. The imaging component may be an RGB Camera **30** or two RGB cameras **30'**, or one depth camera **30''**, for example.

[00154] The movement of the camera may be used, for example, to assess depth using parallax measurements, to stitch together images in generating a 3D model, etc.

[00155] Game monitoring server **20** implements a chip recognition process to determine the number of chips for each betting area and the total value of chips for the betting area. For example, when a new hand is detected at a gaming table, bet recognition device **30** captures image data of each bet area on the gaming table surface and sends the captured image data to game monitoring server **20**.

[00156] In some embodiments, bet recognition device **30** isolates image data for each bet area from image data for a larger portion of the gaming table surface and sends cropped image data only for the bet area to the game monitoring server **20**. In other embodiments, game monitoring server **20** isolates image data for each bet area from image data for a larger portion of the gaming table surface.

[00157] Game monitoring server **20** processes each image frame of the captured image data and segments image data defining chips for each chip by size and color to determine a total number of chips for the betting area. Game monitoring server **20** detects a face value for each chip. Data records of data store **70** may link color and size data to face value. Game monitoring server **20** may also implement number recognition on the image data for chips to detect face value. Game monitoring server **20** calculates the total value of the bet by multiplying the number of chips detected by the face value of the chips.

[00158] **FIGS. 13A, 13B** and **14** illustrate example images taken from a bet recognition device mounted on a gaming table and processed images after transformation by server according to some embodiments. The images **1300A**, **1300B**, and **1400** illustrate segments generated by the game monitoring server **20** to determine the number of chips and the face value of the chips. Game monitoring server **20** stores the bet data in data store **70**.

[00159] Chips **1300-1314** may be processed by size, and color (e.g., in this example, **1302** is a different type of chip than the others), and the sensors and/or imaging components may obtain data, including images in visual spectrum or non-visual spectrum. For example, some markings may be only shown in infrared or ultraviolet, or may fluoresce in response to the reference illumination applied to the chips. Texture and shape, in some embodiments, are also tracked based on visually apparent features.

[00160] As depicted in **FIG. 13B**, the images may be processed such that the sidewalls of the chips can be analyzed, by identifying a region of interest represented, for example, by the pixels

within a "bounding box" **1316** and **1316'** around each of the chips. Depending on the amount of available resources, the determination of the region of interest may be conducted at a backend server, or during pre-processing on a device coupled to the gaming table, in various embodiments.

[00161] Game monitoring server **20** watches for new captured image data for the bet area and processes the new captured images against existing data records for bet data stored in data store **70**. Chips in the bet area are checked for size, shape, and color to ensure accuracy. **FIGS. 13** and **14** illustrate that only the chips in the bet area are detected by the game monitoring server **20** bet recognition process. Once processing is completed, the game monitoring server **20** sends the bet values of each bet area or region to the data store **70**. In some example embodiments, game monitoring server **20** associates a hand identifier to the bet data values. A timestamp may also be recorded with the bet data values stored in data store **70**.

[00162] Embodiments described herein provide a bet recognition device **30** with both an imaging component and a sensor component. Bet recognition device **30** captures image and sensor data for provision to gaming monitoring server **20** to calculate bet data.

[00163] **FIG. 15** illustrates a schematic diagram **1500** of a sensor array device for bet recognition device according to some embodiments. A bet recognition device may include a microcontroller, a sensor array network and connection cables. The microcontroller may run the logic level code for checking onboard sensors (e.g. sensors integrated into the gaming tables via client hardware devices **30**) for pre-defined thresholds triggering capture of image data to determine bet data. The microcontroller may also emulate a serial communication protocol for the host. The sensor array network may include interconnected sensors that can communicate with each other. The sensors may be integrated with a gaming table and positioned relative to playing area of the table. They may be all connected via the microcontroller and routed accordingly. A connection cable may process the digital serial signal and allow the device to connect via USB or other protocol (e.g. wireless) to a computer with a free port. The data may be transmitted via the USB cable or other protocol and may be read by a small utility on the host computer.

[00164] **FIG. 16** illustrates a schematic graph **1600** of the amplitude of the received signal from a sensor and/or imaging component over time according to some embodiments.

[00165] The following is an illustrative example measurement setup for a scene point. A sensor estimates the radial distance by ToF or RADAR principle. The distance, ρ, is calculated at time τ with electromagnetic radiation at light speed c, is ρ = cτ. The transmitter emits radiation, which travels towards the scene and is then reflected back by the surface to the sensor receiver. The distance covered is now 2ρ at time T. The relationship can be written as:

$$p = \frac{c\tau}{2}$$

[00166] Signal $S_E(t)$ may be reflected back by the scene surface and travels back towards a receiver (back to receiver) and written as:

$$S_E(t) = A_E[2\pi f_{\text{mod}} t]$$

[00167] Because of free-path propagation attenuation (proportional to the square of the distance) and the non-instantaneous propagation of IR optical signals leading to a phase delay $\Delta\Phi$. The Attenuated Amplitude of received signal may be referred to as A_R. The interfering radiation at IR wavelength of emitted signal reaching the receiver may be referred to as B_R.

[00168] Waveforms may be extracted in relation to each chip (e.g., as extracted from the available pixels in image data for each channel of information), and these waveforms may represent, for example, information extracted from histogram information, or from other image information. For example, a Fourier transform may be conducted on the image data separately from extracted histogram information. In some embodiments, a histogram and a Fourier transform are used in combination.

[00169] A best-matching waveform approach may be utilized to estimate which color and/or markings are associated with a particular chip. For example, each chip may have a corresponding waveform (for each image channel) and these may be used, in some embodiments, in aggregate, to classify the chips based on chip values. In some embodiments, where the data is not sufficiently distinguishing between different chip values (e.g., poor lighting makes it difficult to distinguish between pink and red), the system may be adapted to provide a confidence score associated with how closely matched the waveform is with a reference template. This confidence score, for example, may be used to modify sensory characteristics,

lighting conditions, etc., so that the confidence score may be improved on future image processing. In some embodiments, the interfaces provided to users may also utilize the confidence score in identifying how strong of a match was determined between chip images and reference templates. The received signals **1602** and **1604** may be different for each type of chip, and the waveforms may be processed through a classifier to determine a "best match". As described in some embodiments, the confidence in determining a best match may be based on (1) how well matched the chip is to a reference waveform, and (2) how much the chip is able to distinguish between two different reference waveforms. The confidence score may be used to activate triggers to improve the confidence score, for example, by automatically activating reference illumination or requesting additional images (e.g., moving the camera to get more pixels due to an obstruction, lengthening a shutter speed to remove effects of motion, temporarily allocating additional processing power to remove noise artifacts).

[00170] **FIG. 17** is an illustration of a schematic of a game monitoring server **20** according to some embodiments.

[00171] Game monitoring server **20** is configured to collect game event data including bet data and hand start data and hand stop data, which may be referred to generally as hand event data. The hand event data may be used to determine a hand count (e.g., the number of hands played by various players) for a particular gaming table for a particular period of time. Bet and hand count data may be associated with a time stamp (e.g., start time, stop time, current time) and table identifier. The bet data may also be associated with a particular player (e.g. dealer, customer) and a player identifier may also be stored in the data structure.

[00172] For simplicity, only one game monitoring server **20** is shown but system may include more game monitoring servers **20**. The game monitoring server **20** includes at least one processor, a data storage device (including volatile memory or non-volatile memory or other data storage elements or a combination thereof), and at least one communication interface. The computing device components may be connected in various ways including directly coupled, indirectly coupled via a network, and distributed over a wide geographic area and connected via a network (which may be referred to as "cloud computing").

[00173] For example, and without limitation, the computing device may be a server, network appliance, set-top box, embedded device, computer expansion module, personal computer,

laptop, or computing devices capable of being configured to carry out the methods described herein.

[00174] As depicted, game monitoring server **20** includes at least one game activity processor **80**, an interface API **84**, memory **86**, at least one I/O interface **88**, and at least one network interface **82**.

[00175] Game activity processor **80** processes the game activity data including image data, bet data, and so on, as described herein. Each processor **80** may be, for example, a microprocessor or microcontroller, a digital signal processing (DSP) processor, an integrated circuit, a field programmable gate array (FPGA), a reconfigurable processor, a programmable read-only memory (PROM), or any combination thereof.

[00176] Memory **86** may include a suitable combination of computer memory that is located either internally or externally such as, for example, random-access memory (RAM), read-only memory (ROM), compact disc read-only memory (CDROM), electro-optical memory, magneto-optical memory, erasable programmable read-only memory (EPROM), and electrically-erasable programmable read-only memory (EEPROM), Ferroelectric RAM (FRAM) or the like.

[00177] Each I/O interface **88** enables game activity processor **80** to interconnect with one or more input devices, such as a keyboard, mouse, camera, touch screen and a microphone, or with one or more output devices such as a display screen and a speaker.

[00178] Each network interface **82** enables game activity processor **80** to communicate with other components, to exchange data with other components, to access and connect to network resources, to serve applications, and perform other computing applications by connecting to a network (or multiple networks) capable of carrying data including the Internet, Ethernet, plain old telephone service (POTS) line, public switch telephone network (PSTN), integrated services digital network (ISDN), digital subscriber line (DSL), coaxial cable, fiber optics, satellite, mobile, wireless (e.g. Wi-Fi, WiMAX), SS7 signaling network, fixed line, local area network, wide area network, and others, including any combination of these.

[00179] Application programming interface (API) **84** is configured to connect with front end interface **60** to provide interface services as described herein.

[00180] Game activity processor **80** is operable to register and authenticate user and client devices (using a login, unique identifier, and password for example) prior to providing access to applications, network resources, and data. Game activity processor **80** may serve one user/customer or multiple users/customers.

[00181] **FIG. 18**. illustrates a schematic of a bet recognition device **30** according to some embodiments.

[00182] As depicted, bet recognition device **30** may include an imaging component **90**, sensor component **92**, processor **91**, memory **94**, at least one I/O interface **96**, and at least one network interface **98**.

[00183] Processor **91** may be, for example, any type of general-purpose microprocessor or microcontroller, a digital signal processing (DSP) processor, an integrated circuit, a field programmable gate array (FPGA), a reconfigurable processor, a programmable read-only memory (PROM), or any combination thereof.

[00184] Memory **94** may include a suitable combination of any type of computer memory that is located either internally or externally such as, for example, random-access memory (RAM), read-only memory (ROM), compact disc read-only memory (CDROM), electro-optical memory, magneto-optical memory, erasable programmable read-only memory (EPROM), and electrically-erasable programmable read-only memory (EEPROM), Ferroelectric RAM (FRAM) or the like.

[00185] Each I/O interface **96** enables bet recognition device **30** to interconnect with one or more input devices, such as a keyboard, mouse, camera, touch screen and a microphone, or with one or more output devices such as a display screen and a speaker.

[00186] Each network interface **98** enables bet recognition device **30** to communicate with other components, to exchange data with other components, to access and connect to network resources, to serve applications, and perform other computing applications by connecting to a network.

[00187] Bet recognition device **30** may also include a scale component. Bet recognition device **30** may monitor chips and cards on the gaming table using scales. A scale may be placed underneath the casino table, or underneath the area on which the chips or cards are placed. The scale may take measurements during the time periods when no movement of the chips or cards

is done. For example, a dealer may and the players may place the cards or chips on the table, upon seeing a particular gesture, a scale may read the weight and the system may determine, based on the weight, as well as the monitoring mechanism, the number of cards or chips on the table. The weight reading may be done at a later point, to confirm that no cards or chips were taken off of the table. The scale may take measurements of the weight responsive to a command by the system. As such, the system may determine when the chips or cards are not touched by the dealer or the player, thereby ensuring that a correct measurement is taken and, in response to such a determination, sending a command to measure the weight of the chips or cards. As an example, based on the weight and the coloring of the chips, the system may determine the present amount of the chips the user may have. This may be an example of game activity.

[00188] Using these techniques, the system may monitor and track not only the chips of the dealers but also the chips of the players, may track the progress of each player, may be able to see when and how each player is performing, and may also monitor new hands to determine hand count. The system may therefore know the amount of chips gained or lost in real time at any given time, and may also know the number of cards in each player's hand, and so on.

[00189] As described herein, embodiments described herein may provide systems, methods and devices with bet recognition capabilities. Bet recognition data may be generated and collected as game event data and may be connected to hand count data. For example, a hand may involve betting chips and system may detect chips using bet recognition device **30**.

[00190] The bet recognition device may capture image data for bet data in response to chip detection in a betting region.

[00191] The system may involve bet recognition cameras inside of a bumper of the gaming table on the dealer's side. The cameras may be in nearly the same location as this may simplify table retrofitting. All of components including computers for both bet recognition and hand count may be installed there.

[00192] **FIGS. 19** to **39**, **51** and **52** illustrate schematic diagrams of bet recognition devices and imaging components according to some embodiments.

[00193] Embodiments described herein may implement bet recognition devices and imaging components with different camera positioning options.

[00194] For example, a bet recognition device may have an imaging component with one wide-angle lens camera at the back of the table that scans the entire casino table. An example schematic **1900** is shown in **FIG. 19** including illustrative lines corresponding to a field of view for the camera.

[00195] As another example, a bet recognition device may have an imaging component with three cameras at the back of the table (e.g. left, middle, right), pointing outward towards the player positions.

[00196] An illustrative schematic of an imaging component **3200** and **3300** with three cameras is shown in **FIGS. 32** and **33**. An example table layout is shown in **FIG. 28**. Example playing areas for image capture is shown in **FIGS. 29** to **31**. For example, there may be **21** or **28** playing areas for image capture for seven players with three or four playing areas allocated per player. The playing areas may be for bets, chips, cards, and other play related objects. As shown, fields of view for cameras may overlap such that one or more cameras may capture image data corresponding to each play area. For example, two cameras may capture image data corresponding to a play area. As another example, three cameras may capture image data corresponding to a play area.

[00197] As shown in **FIGS. 21** to **27** a dealer may place cards on the table within one or more fields of view of cameras to capture image data relating to cards, dealer card play, and dealer gestures. The image data captured by different cameras with overlapping fields of view may be correlated to improve gesture recognition, for example.

[00198] An example is shown in **FIGS. 20** to **31** including illustrative lines corresponding to fields of view for the cameras. As shown in **2000** and **2100**, there may be overlapping fields of view between cameras. **FIGS. 24A-24D** (shown in images **2400A-2400D** illustrate a dealer at a table undertaking motions to serve cards in relation to a card game. The dealer's motions may temporarily obstruct various betting areas, and it may be advantageous to have overlapping fields of view to account for such obstruction. In some embodiments, where there is a single camera, the shutter speed may be slowed so that the dealer's motions are removed during processing. Similarly, **FIGS. 25A-25E**, and **FIGS. 26 and 27** at **2500A-2500E, 2600** and **2700** show alternate dealing motions.

[00199] **FIGS. 28-31** illustrate how a computing system may track the various betting areas. As provided in the diagrams **2800**, **2900**, **3000,** and **3100**, a bet recognition system may utilize imaging components and/or sensors that process images from the perspective of a dealer. As depicted, three different cameras may be used, each tracking one or more different betting areas that are associated with each player. There may be multiple betting areas that a player may be in (e.g., craps). As indicated in **FIG. 30** and **FIG. 31**, the fields of view may overlap for the cameras. The overlapping field of view may aid in increasing the confidence score of a particular bet analysis.

[00200] As a further example, a bet recognition device may have an imaging component with three cameras at the back of the table (e.g., left, middle, right), pointing inward. An example **3400** is shown in **FIG. 34** including illustrative lines corresponding to fields of view for the cameras.

[00201] As another example, a bet recognition device may have an imaging component with three cameras in the middle of the table (left, middle, right), pointing outward. An example **3500** is shown in **FIG. 35** including illustrative lines corresponding to fields of view for the cameras.

[00202] As an additional example, a bet recognition device may have an imaging component with two cameras at the back of the table (left and right), pointing inward. An example **3600** is shown in **FIG. 36** including illustrative lines corresponding to fields of view for the cameras.

[00203] As an additional example, a bet recognition device may have an imaging component with seven endoscope cameras placed at the front of the table, between the players and the betting area, pointing inward. Examples **3700** and **3900** are shown in **FIGS. 37** and **39**. Example hardware components **3802-3808** for implementing an example imaging component are shown in **FIG. 38**. **FIG. 39** illustrates an alternate embodiment **3900** wherein cameras are positioned differently.

[00204] Endoscopes may be augmented by mirrors and light emitters in some example embodiments. The use of endoscopes may be an effective method for achieving high accuracy when analyzing chips as the cameras are located closest to the betting area as possible with no obstructions. However, the effort required to retrofit existing casino tables with endoscopes may be arduous to be practical in some situations. Accordingly, different example camera implementations may be used depending on the situation.

[00205] When capturing imaging data of the betting area for the purposes of analyzing the number and value of a player's chips, the cameras may capture images using infrared (IR) technology which is not visible to the human eye. The cameras may use IR emitters and receivers which can operate on the same wavelength. Further, the cameras may be programmed to capture images at different times so that the wavelengths do not interfere with one another, making sure that each image is not obstructed.

[00206] In another aspect, embodiments described herein may provide automatic calculation of manual casino shoes and associated statistics including, for example, shuffle per hour.

[00207] The "casino shoe" is the card release mechanism on casino tables, which may contain several decks of cards. Dealers use the casino shoe to source cards for dealing each hand.

[00208] A casino "shoe" may be monitored by hardware components to provide a measure of how many shuffles occurred per hour, how many cards were dealt to players (including the dealer) per hour, and so on. For example, to count cards on a manual shoe, a magnet and a magnetic sensor may be attached to the shoe and used to trigger when the shoe is empty of cards.

[00209] Alternatively, a dealer procedure could require the shoe to be turned on its side with the shoe weighted wedge removed. This can be recognized with the retrofitting of the tilt switch (i.e., single-axis gyroscope) inside or outside of the shoe. This may recognize when a shoe has been depleted and must be refilled. The bet recognition device **20** can thus collect data on cards such as, for example, how many shuffles occur per hour (which varies because shoes are depleted at different depths based on different gameplay scenarios) and indicate when the bet recognition process does not need to look for player bets.

[00210] Embodiments described herein automate the process of counting "shoe" related statistics (e.g., the number of shoes). Prior attempts may require data to be collected manually by the pit manager

[00211] **FIG. 40** illustrates that a shoe **4000** may be positioned at various inclines (increasing, decreasing). **FIGS. 41** to **43** illustrate different views **4100**, **4200**, **4300** of a card shoe which may be used in example embodiments. **FIGS. 44** to **46C** illustrate different example positions **4400, 4500, 4600A-4600C** of a card shoe on a gaming table according to some example embodiments.

[00212] In another aspect, embodiments described herein may provide background image subtraction and depth segmentation. Background subtraction is a computational technique used according to embodiments described herein to differentiate the background image from the foreground image when capturing image data of the casino table. Depth segmentation is another technique that may achieve accuracy in analyzing a specific image data of a three-dimensional area of the betting table. This technique allows embodiments described herein to establish a region of analysis on the casino table and to narrow the focus of the camera onto the betting area, without incorporating the chips not relating to that player's bet (e.g., in another betting area, or out of play altogether). This area may be referred to as a "bounding box".

[00213] This is one of different example ways to perform the removal of the background of an image when establishing a "bounding box" to identify the number and types of chips in a betting area. Other example techniques include graph cut, frame differencing, mean filtering, Gaussian averaging, background mixture models, and so on.

[00214] After capturing two-dimensional images with a camera embedded in the casino table, background subtraction can be run as an automatic algorithm that first identifies the boundaries of object, and then allows the software to separate that object (e.g., chips, hands, or any other objects commonly found on the casino floor) from its background.

[00215] To increase the effectiveness of background subtraction, embodiments described herein may support three-dimensional background subtraction, making use of depth data to differentiate the foreground image from the background (illuminating the object with infrared and/or using lasers to scan the area).

[00216] Based on the distortion of the light, after projecting light onto the object, embodiments described herein can determine how far away an object is from the camera, which helps to differentiate the object from its background in two-dimensional and three-dimensional images.

[00217] In a further aspect, embodiments described herein may count the number of stacks of chips placed in the betting area.

[00218] Embodiments described herein may be used to administer casino standards for how players should place their stacks of chips. Known approaches require this to be checked manually by a dealer before a hand can begin.

[00219] Embodiments described herein may have the capacity to accurately collect data on every hand by counting the chips and their value. Embodiments described herein may have the ability to establish the quality of betting by using depth cameras to capture errors made by players.

[00220] Embodiments described herein may scan and accurately count any type of chips, including but not limited to four example varietals: no stripes, all different colors; stripes, but all the same on all chips (different colours); varying colors and stripes (stripes are smeared); and different colors and stripes (stripes are well-defined). **FIGS. 47** and **48** show example views of chip stacks.

[00221] When a camera is elevated above the level of the table, embodiments described herein may be programmed to detect the top of the chip first. An example is shown in **FIG. 49**. Once the system has recognized the top of the chip, the process can quickly count top-down to establish an accurate chip count and then shift to scan bottom-up to identify the value of all these chips. This may be important due to several example features. Several cameras according to embodiments described herein may be elevated above the tabletop (e.g., looking past the dealer's body, midway up the torso). This allows the system to recognize the betting area by establishing a "bounding box", which is an area on the betting table that is scanned by to analyze physical objects, i.e., the chips.

[00222] In some casino games, such as baccarat, other chip stacks on the table may obstruct players' bets from the camera's view, so the process may encounter obstruction. To solve this, cameras placed at elevated angles may allow embodiments described herein to see more of table and maintain high accuracy.

[00223] In another aspect, embodiments described herein may determine chip stack sequence in a betting area.

[00224] When bets are being placed in betting areas, embodiments described herein may have the capacity to capture data on the visual sequence of the chips when players place them in the betting area.

[00225] Embodiments described herein may take pointed pictures (e.g. image data) of varying stripe patterns on a cylinder (e.g. the shape of the chip stack), which can vary in pixel number. In accordance with embodiments, to optimize the speed and accuracy of recognizing chips, the

system may benchmark the size of image captures at 3 by N pixels for height and width measurements, in some examples. Other benchmarks may be used.

[00226] Embodiments described herein may accurately recognize when a frequency signature is present and also allows for the training of new stripe patterns, for example.

[00227] Embodiments described herein may recognize and confirm this pattern by using a camera to see the sequence of the stripes, as well as the color of the chips. The system may be configured to be precise enough to register the specific hue of the chip, which is relevant for the system in terms of both accuracy of results and security purposes.

[00228] The casino standard of chip stack sequence may typically have players bet in a specific order: highest value chips on the bottom of the stack, with lower value chips layered upward. **FIG. 50** shows a chip stack with this example standard.

[00229] Beyond recognizing the typical pattern (e.g., highest value on bottom, lowest on top (see **FIG. 50**) embodiments described herein may use Fourier analysis to find different types of chip, applying learnable frequency/discrete signal patterns on the chip stack. Embodiments described herein may also combine with Neural Networks or equivalent learning techniques to identify when the pattern is present. By preprogramming the process to recognize particular nodes of the neural network relating to chips, Embodiments described herein can also deactivate specific nodes so that they are not optional paths in the decision process, which may improves both speed and accuracy.

[00230] This feature also enables embodiments described herein to "turn off" certain classes or types of chips during its analysis of stack sequence, so that it does not search for particularly values of chip. This has the effect of increasing the speed of the 'chip stack sequence' process while maintaining accuracy.

[00231] By training multiple classifiers, embodiments described herein can automatically remove the last highest chip value from each stack sequence to increase the speed of analysis. Each time the algorithm scans the chip stack, it may run the example sequence as follows: 12345 (scanning all chips), 1234 (removing a value), 123 (removing another value), 12 (etc.), 1 (etc.), and finally removing all chip classifiers during its last scan. By removing values over multiple analyses, embodiments described herein may not look for certain values when they are not

present in a player's bet. This may enable the process to increase its operation speed over time while maintaining accuracy.

[00232] Embodiments described herein may also recognize player errors on the occasions when the stack sequence does not meet the casino standard.

[00233] If the player makes an error or a failure to meet the standards of the casino, embodiments described herein may log that error and may generate an electronic alert for transmission to a casino manager to provide an alert of the error. The automatic alert may depend on the severity of the error.

[00234] Embodiments described herein may also detect between different versions of a chip using pattern recognition and signal processing techniques. For example, different colors and patterns on chips may have different frequencies of image data and which may be used to detect different versions of chips.

[00235] Embodiments described herein may also detect when chips require cleaning. With the same frequency image techniques used for detecting different versions of the chip, embodiments described herein may also detect when dirt has built up on chips. The build-up of debris on the chips disrupts the frequency of its colour as captured by the camera.

[00236] Embodiments described herein may also use mirrors on casino tabletops as part of the image capture component of bet recognition device **20**.

[00237] Embodiments described herein may require two spaces on the surface top of a casino table to run at its top capacity.

[00238] To make these spaces smaller, one approach may be to use mirrors on the table surface to reflect the camera illumination technology onto the chips, enabling embodiments described herein to effectively differentiate the object from the background to enable the chip counting process, and other applications, to run at high capacity. Adding mirrors to the tabletop can help improve aesthetics, enable easier retrofit, and make embodiments described herein less obtrusive to the dealer and players.

[00239] Embodiments described herein may be described in relation to blackjack as an illustrative example. However, embodiments described herein may analyze other casino games.

[00240] For example, Baccarat is another game at the casino that the presently disclosed system can be used to analyze. Baccarat is a comparing card game played between two hands on the table, the player's and the banker's. Each hand of baccarat has three possible outcomes: "player" win, "banker" win, and "tie".

[00241] Embodiments described herein may obtain additional info about the hand on the table, in addition to the bet information, such as what cards the dealer and player had in their hands. Embodiments described herein may determine what a player bets, and whether the player has won, lost, or tied.

[00242] By providing more accurate account of table dynamics, embodiments described herein may be essential for improving a casinos understanding of the process of how people are playing baccarat.

[00243] **FIG. 53** is an example workflow **5300**, illustrative of some embodiments. **FIG. 53** is an example workflow **5300** illustrative of some embodiments. Workflow **5300** includes various steps, and the steps provided are examples, and different, alternate, less, more steps may be included. While steps may be performed in the order depicted, other orders may be possible. **5300** is a process for extracting and saving bet data as obtained from image data. The recognition process **5302** and the feature extraction profess **5304** are provided as examples, illustrative of example steps that may be utilized to determine a chip count result.

[00244] **FIG. 54** is an example workflow **5400** illustrative of some embodiments. Workflow **5400** includes various steps, and the steps provided are examples, and different, alternate, less, more steps may be included. While steps may be performed in the order depicted, other orders may be possible. **5400** is a process for extracting and saving bet data as obtained from image data. At **5402**, coordinates are obtained in relation to the bets as represented by chips in the betting areas. For example, coordinates may include chip height, chip width, and a horizon element that may be expressed in the form of pixels. The coordinates may be utilized to obtain lists of pixels for sampling from the images, generating a sample space using the list of pixels. Connected components are calculated from the sample space, and centroids are calculated for each of the connected components. At **5404**, coordinate information is extracted. Extraction may include creating headers for coordinate information feature, mapping sample coordinates into a region of interest space into an original color image space, and creating a list of mapped coordinates. At **5406**, the system is configured to create an empty ground truth feature, which is a set of data

values that are normalized so that values can be compared against reference feature points. At **5408**, features are extracted, and at **5410**, coordinate information, ground truth and customized feature sets are concatenated and converted to a dataframe at **5412**. The customized feature sets are derived, for example, in relation to distinguishing features of chip markings that may vary between different facilities and the types of chips being utilized.

[00245] **FIG. 55** is an example workflow **5500** illustrative of some embodiments. Workflow **5500** includes various steps, and the steps provided are examples, and different, alternate, less, more steps may be included. While steps may be performed in the order depicted, other orders may be possible. **5500** is a process for counting bet data as obtained from image data. At **5502**, images are loaded from a data storage. During the image loading step, color images may be obtained, and in some embodiments, depth and/or infrared imaging is obtained. A transformation matrix is calculated, and the color image is read. At **5504**, labels are loaded onto the images (labels are originally blank, and will be updated when the regions of interest in the images are classified), and at **5506**, features are extracted from the loaded images and labels. The feature extraction process, for example, may utilize a trained classifier wherein random colors may be assigned to classes to distinguish between different classes. During the feature extraction process, one or more lines (e.g., vertical, horizontal, diagonal) are used for sampling pixels and/or dot representations of the chips.

[00246] In some embodiments, the chip pixels themselves in a region of interest representing a particular chip are blurred and/or otherwise aggregated so that the sampled regions are more likely representative of the chip in its entirety. Such an approach may reduce the number of pixels required for analysis and/or storage, increasing the speed and efficiency of classification. The dots and the pixels may therefore represent adjacent colours, and based on the height and distance, the number of chips can be determined, and each chip can be segregated by dividing the height of a stack by the height of a chip, creating individual chip segments. In some embodiments, the sample line is a 1D line of color / histogram values, and in other embodiments, a long 2D line having a length and a width of values are extracted.

[00247] This approach may be helpful where gaming facilities release different versions of chips, often differentiated by subtle differences in hue (e.g., changing the frequency of color as captured by the imaging component), or in the sequence of markings, such as stripes.

[00248] Accordingly, in some embodiments, classification include normalizing the pixel values of an image capture, gamma-decoding the image such that pixel values are proportional to the number of photos impacting the camera sensor, combining the pixels in the height dimension into a single 1D line, which is then truncated to form a uniform width for a Fast Fourier Transform analysis. Such an approach may also include classification based, for example, at least on the magnitude of the complex sinusoids returned.

[00249] Colors, among other visual markers, may be mapped to various classes. At **5508**, chips are classified (e.g., based on machine-vision derived estimations). The system may also be trained to differentiate between new versions of chips from obsolete versions of chips, which may be removed from circulation to maintain security and consistency.

[00250] At **5510**, chips are counted through based on the classifications, and at **5512**, chip counts are printed to a file (e.g. encapsulated and/or encoded for transmission to downstream systems).

[00251] **FIG. 55** is an example workflow **5500** illustrative of some embodiments. Workflow **5500** includes various steps, and the steps provided are examples, and different, alternate, less, more steps may be included. While steps may be performed in the order depicted, other orders may be possible.

[00252] At **5502**, detecting, by an imaging component, that one or more chips have been placed in one or more defined bet areas on a gaming surface, each chip of the one or more chips having one or more visual identifiers representative of a face value associated with the chip, the one or more chips arranged in one or more stacks of chips.

[00253] At **5504**, capturing, by the imaging component, image data corresponding to the one or more chips positioned on the gaming surface, the capturing triggered by the detection that the one or more chips have been placed in the one or more defined bet areas.

[00254] At **5506**, transforming, by an image processing engine, the image data to generate a subset of the image data relating to the one or more stacks of chips, the subset of image data isolating images of the one or more stacks from the image data.

[00255] At **5508**, recognizing, by an image recognizer engine, the one or more chips composing the one or more stacks, the recognizer engine generating and associating metadata

representative of (i) a timestamp corresponding to when the image data was obtained, (ii) one or more estimated position values associated with the one or more chips, and (iii) one or more face values associated with the one or more chips based on the presence of the one or more visual identifiers.

[00256] At **5510** segmenting, by the image recognizer engine, the subset of image data and with the metadata representative of the one or more estimated position values with the one or more chips to generate one or more processed image segments, each processed image segment corresponding to a chip of the one or more chips and including metadata indicative of an estimated face value and position.

[00257] At **5512**, determining, by a game monitoring engine, one or more bet data values, each bet data value corresponding to a bet area of the one or more defined bet areas, and determined using at least the number of chips visible in each of the one or more bet areas extracted from the processed image segments and the metadata indicative of the face value of the one or more chips.

[00258] The advantages of the some embodiments are further illustrated by the following examples. The examples and their particular details set forth herein are presented for illustration only and should not be construed as limitations.

[00259] In implementation, the process of patching together images may begin with capturing a particular number of samples from each camera that is mounted to the table.

[00260] Different scenarios of chips are used for each sample. These scenarios also include extreme situations so that the machine can learn, which allows it to handle simpler scenarios with a greater relative ease. The captured samples are then labeled by denomination to create the file that is used in training.

[00261] The capturing tools developed by the Applicant have been capable of focusing mainly on the bet area, while omitting any surrounding environments that might cause discrepancies. The removal of surrounding environments helps the system to ignore any background chips during training and testing processes.

[00262] During testing, it was noted that the removal of background chips improved accuracy. In the process of training and testing, higher accuracy of datasets and successful training were

found through capturing and labelling samples in a brightly lit setting and testing them in a dimly lit setting, or executing both processes in a brightly lit setting. This approach was found to produce a higher accuracy than performing both of the process in a dimly lit setting or performing the first process in a dimly lit setting while next in bright light.

[00263] Applicant also found that providing more light from the side helped the system identify colors better.

[00264] The embodiments of the devices, systems, and methods described herein may be implemented in a combination of both hardware and software. These embodiments may be implemented on programmable computers, each computer including at least one processor, a data storage system (including volatile memory or non-volatile memory or other data storage elements or a combination thereof), and at least one communication interface.

[00265] Program code is applied to input data to perform the functions described herein and to generate output information. The output information is applied to one or more output devices. In some embodiments, the communication interface may be a network communication interface. In embodiments in which elements may be combined, the communication interface may be a software communication interface, such as those for inter-process communication. In still other embodiments, there may be a combination of communication interfaces implemented as hardware, software, and combination thereof.

[00266] Throughout the foregoing discussion, numerous references will be made regarding servers, services, interfaces, portals, platforms, or other systems formed from computing devices. It should be appreciated that the use of such terms is deemed to represent one or more computing devices having at least one processor configured to execute software instructions stored on a computer readable tangible, non-transitory medium. For example, a server can include one or more computers operating as a web server, database server, or other type of computer server in a manner to fulfill described roles, responsibilities, or functions.

[00267] The discussion provides many example embodiments. Although each embodiment represents a single combination of inventive elements, other examples may include all possible combinations of the disclosed elements. Thus if one embodiment comprises elements A, B, and C, and a second embodiment comprises elements B and D, other remaining combinations of A, B, C, or D, may also be used.

[00268] The term “connected” or "coupled to" may include both direct coupling (in which two elements that are coupled to each other contact each other) and indirect coupling (in which at least one additional element is located between the two elements).

[00269] The technical solution of embodiments may be in the form of a software product. The software product may be stored in a non-volatile or non-transitory storage medium, which can be a compact disk read-only memory (CD-ROM), a USB flash disk, or a removable hard disk. The software product includes a number of instructions that enable a computer device (personal computer, server, or network device) to execute the methods provided by the embodiments.

[00270] The embodiments described herein are implemented by physical computer hardware, including computing devices, servers, receivers, transmitters, processors, memory, displays, and networks. The embodiments described herein provide useful physical machines and particularly configured computer hardware arrangements. The embodiments described herein are directed to electronic machines and methods implemented by electronic machines adapted for processing and transforming electromagnetic signals which represent various types of information. The embodiments described herein pervasively and integrally relate to machines, and their uses; and the embodiments described herein have no meaning or practical applicability outside their use with computer hardware, machines, and various hardware components. Substituting the physical hardware particularly configured to implement various acts for non-physical hardware, using mental steps for example, may substantially affect the way the embodiments work. Such computer hardware limitations are clearly essential elements of the embodiments described herein, and they cannot be omitted or substituted for mental means without having a material effect on the operation and structure of the embodiments described herein. The computer hardware is essential to implement the various embodiments described herein and is not merely used to perform steps expeditiously and in an efficient manner.

[00271] Although the embodiments have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein.

[00272] Moreover, the scope of some embodiments is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from some embodiments, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same

function or achieve substantially the same result as the corresponding embodiments described herein may be utilized. Accordingly, embodiments are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

[00273] As can be understood, the examples described above and illustrated are intended to be exemplary only.

WHAT IS CLAIMED IS:

1. A computer implemented method for monitoring betting activities comprising:

detecting that one or more chips have been placed in one or more defined bet areas on a gaming surface, each chip of the one or more chips having one or more visual identifiers representative of a face value associated with the chip, the one or more chips arranged in one or more stacks of chips in the one or more defined bet areas;

capturing image data corresponding to the one or more chips placed in the one or more defined bet areas, the capturing triggered by the detection that the one or more chips have been placed in the one or more defined bet areas;

transforming the image data to generate a subset of the image data relating to the one or more stacks of chips, the subset of image data isolating images of the one or more stacks from background image data in the image data;

machine recognizing the one or more chips arranged in the one or more stacks and generating metadata representative of (i) a timestamp corresponding to when the image data was obtained, (ii) one or more estimated position values associated with the one or more chips, and (iii) one or more face values associated with the one or more chips based on the presence of the one or more visual identifiers;

segmenting the subset of image data with the metadata representative of the one or more estimated position values with the one or more chips to generate one or more processed image segments, each processed image segment corresponding to a chip of the one or more chips and including metadata indicative of an estimated face value and position;

determining one or more bet data values, each bet data value corresponding to a bet area of the one or more defined bet areas, and determined using at least the number of chips visible in each of the one or more bet areas extracted from the processed image segments and the metadata indicative of the face value of the one or more chips; and

generating, a three-dimensional model of the gaming surface, the three-dimensional model including an extrapolation of obtained image data; and

wherein the one or more chips are recognized using at least the three-dimension model.

2. The method of claim 1, the method further comprising:

transmitting, the one or more bet data values corresponding to the one or more defined bet areas, to a gaming data repository, the game data repository configured for associating the one or more bet data values to one or more bets made by one or more players as the one or more players interact with a game being played on the gaming surface; and

generating, on a display of a computing device by n interface component, an electronic dashboard illustrative of at least one of current and historical bets made by the one or more players.

3. The method of claim 1, wherein, for chips of the one or more chips that are partially obscured from the imaging component, extrapolating an entirety of each obscured chip in the three-dimensional model.

4. The method of claim 1, wherein the recognizing of one or more face values associated with the one or more chips based on the presence of the one or more visual identifiers includes comparing the one or more visual identifiers with reference records in relation to at least one of size, shape, and color.

5. The method of claim 1, wherein the one or more processed image segments identifies the one or more chips by establishing a bounding box around visual contours of each of the one or more chips.

6. The method of claim 1, wherein the imaging component includes a plurality of cameras, and wherein the image processing engine combines together image data captured by the plurality of cameras.

7. The method of claim 1, wherein the transforming of the image data to generate the subset of image data includes at least using three-dimensional background subtraction to differentiate one or more foreground images from a background.

8. The method of claim 7, wherein the one or more chips are illuminated using at least one of infrared light and lasers.

9. The method of claim 1, wherein the imaging component comprises two or more cameras for installation at a gaming table with the gaming table surface.

10. The method of claim 1, wherein the imaging component comprises two or more cameras for installation in a chip tray or other component of a gaming table with the gaming table surface.

11. The method of claim 1, wherein the imaging component comprises two or more cameras for installation in a back bumper for a gaming table with the gaming table surface.

12. The method of claim 1, wherein each bet recognition device comprises a sensor component.

13. The method of claim 1, wherein each bet recognition device comprises a scale component.

14. The method of claim 1, wherein the server processor is configured to segment the image data to identify chips and their corresponding values.

15. The method of claim 1, wherein the server processor is configured to calculating RGB and Depth Data for chips.

16. The method of claim 1, wherein the imaging component comprises stereo cameras.

17. The method of claim 1, wherein the imaging component comprises depth aware cameras.

18. The method of claim 1, wherein the imaging component comprises wide angle cameras.

19. The method of claim 1, wherein the imaging component comprises a moving camera movable connected to a linear bearing and coupled to a stepper motor to move the camera from one side of the gaming table to the other.

20. The method of claim 1, wherein bet data values are associated with a timestamp.

21. The method of claim 1, wherein bet data values are associated with a hand identifier.

22. The method of claim 1, wherein the imaging component comprises at least one wide angle lens camera.

23. The method of claim 1, wherein the imaging component comprises at least three cameras at a back portion of the gaming table, the cameras pointing outward.

24. The method of claim 1, wherein the imaging component comprises at least three cameras at a back portion of the gaming table, the cameras pointing inward.

25. The method of claim 1, wherein the imaging component comprises at least three cameras at a middle portion of the gaming table, the cameras pointing outward.

26. The method of claim 1, wherein the imaging component comprises at least two cameras at a back portion of the gaming table, the cameras pointing inward.

27. The method of claim 1, wherein the imaging component comprises at least seven endoscope cameras positioned around a circumference of the gaming table.

28. The method of claim 1, wherein each bet recognition device comprises a sensor component for a card shoe.

29. The method of claim 1, wherein each bet recognition device differentiates between different classes or types of chips.

30. The method of claim 1, wherein each bet recognition device determines a sequence of chips in a stack in the betting area.

31. The method of claim 1, wherein each bet recognition device detects different versions of chips in the betting area.

32. The method of claim 1, wherein each bet recognition device detects when chips in the betting area require cleaning.

33. The method of claim 1, wherein each bet recognition device comprises a mirror component.

34. A computer implemented method for monitoring betting activities comprising:

detecting that one or more chips have been placed in one or more defined bet areas on a gaming surface, each chip of the one or more chips having one or more visual identifiers representative of a face value associated with the chip, the one or more chips arranged in one or more stacks of chips in the one or more defined bet areas;

capturing image data corresponding to the one or more chips placed in the one or more defined bet areas, the capturing triggered by the detection that the one or more chips have been placed in the one or more defined bet areas;

transforming the image data to generate a subset of the image data relating to the one or more stacks of chips, the subset of image data isolating images of the one or more stacks from background image data in the image data;

machine recognizing the one or more chips arranged in the one or more stacks and generating metadata representative of (i) a timestamp corresponding to when the image data was obtained, (ii) one or more estimated position values associated with the one or more chips, and (iii) one or more face values associated with the one or more chips based on the presence of the one or more visual identifiers;

segmenting the subset of image data with the metadata representative of the one or more estimated position values with the one or more chips to generate one or more processed image segments, each processed image segment corresponding to a chip of the one or more chips and including metadata indicative of an estimated face value and position; and

determining one or more bet data values, each bet data value corresponding to a bet area of the one or more defined bet areas, and determined using at least the number of chips visible in each of the one or more bet areas extracted from the

processed image segments and the metadata indicative of the face value of the one or more chips;

wherein the transforming of the image data to generate the subset of image data includes at least using three-dimensional background subtraction to differentiate one or more foreground images from a background.

35. The method of claim 34, the method further comprising:

transmitting, the one or more bet data values corresponding to the one or more defined bet areas, to a gaming data repository, the game data repository configured for associating the one or more bet data values to one or more bets made by one or more players as the one or more players interact with a game being played on the gaming surface; and

generating, on a display of a computing device by an interface component, an electronic dashboard illustrative of at least one of current and historical bets made by the one or more players.

36. The method of claim 34, further comprising:

generating, a three-dimensional model of the gaming surface, the three-dimensional model including an extrapolation of obtained image data; and

wherein the one or more chips are recognized using at least the three-dimension model.

37. The method of claim 36, wherein, for chips of the one or more chips that are partially obscured from the imaging component, extrapolating an entirety of each obscured chip in the three-dimensional model.

38. The method of claim 34, wherein the recognizing of one or more face values associated with the one or more chips based on the presence of the one or more visual identifiers includes comparing the one or more visual identifiers with reference records in relation to at least one of size, shape, and color.

39. The method of claim 34, wherein the one or more processed image segments identifies the one or more chips by establishing a bounding box around visual contours of each of the one or more chips.

40. The method of claim 34, wherein the imaging component includes a plurality of cameras, and wherein the image processing engine combines together image data captured by the plurality of cameras.

41. The method of claim 40, wherein the one or more chips are illuminated using at least one of infrared light and lasers.

42. The method of claim 34, wherein the imaging component comprises two or more cameras for installation at a gaming table with the gaming table surface.

43. The method of claim 34, wherein the imaging component comprises two or more cameras for installation in a chip tray or other component of a gaming table with the gaming table surface.

44. The method of claim 34, wherein the imaging component comprises two or more cameras for installation in a back bumper for a gaming table with the gaming table surface.

45. The method of claim 34, wherein each bet recognition device comprises a sensor component.

46. The method of claim 34, wherein each bet recognition device comprises a scale component.

47. The method of claim 34, wherein the server processor is configured to segment the image data to identify chips and their corresponding values.

48. The method of claim 34, wherein the server processor is configured to calculating RGB and Depth Data for chips.

49. The method of claim 34, wherein the imaging component comprises stereo cameras.

50. The method of claim 134, wherein the imaging component comprises depth aware cameras.

51. The method of claim 34, wherein the imaging component comprises wide angle cameras.

52. The method of claim 34, wherein the imaging component comprises a moving camera movable connected to a linear bearing and coupled to a stepper motor to move the camera from one side of the gaming table to the other.

53. The method of claim 34, wherein bet data values are associated with a timestamp.

54. The method of claim 34, wherein bet data values are associated with a hand identifier.

55. The method of claim 34, wherein the imaging component comprises at least one wide angle lens camera.

56. The method of claim 34, wherein the imaging component comprises at least three cameras at a back portion of the gaming table, the cameras pointing outward.

57. The method of claim 34, wherein the imaging component comprises at least three cameras at a back portion of the gaming table, the cameras pointing inward.

58. The method of claim 34, wherein the imaging component comprises at least three cameras at a middle portion of the gaming table, the cameras pointing outward.

59. The method of claim 34, wherein the imaging component comprises at least two cameras at a back portion of the gaming table, the cameras pointing inward.

60. The method of claim 34, wherein the imaging component comprises at least seven endoscope cameras positioned around a circumference of the gaming table.

61. The method of claim 34, wherein each bet recognition device comprises a sensor component for a card shoe.

62. The method of claim 34, wherein each bet recognition device differentiates between different classes or types of chips.

63. The method of claim 34, wherein each bet recognition device determines a sequence of chips in a stack in the betting area.

64. The method of claim 34, wherein each bet recognition device detects different versions of chips in the betting area.

65. The method of claim 34, wherein each bet recognition device detects when chips in the betting area require cleaning.

66. The method of claim 34, wherein each bet recognition device comprises a mirror component.

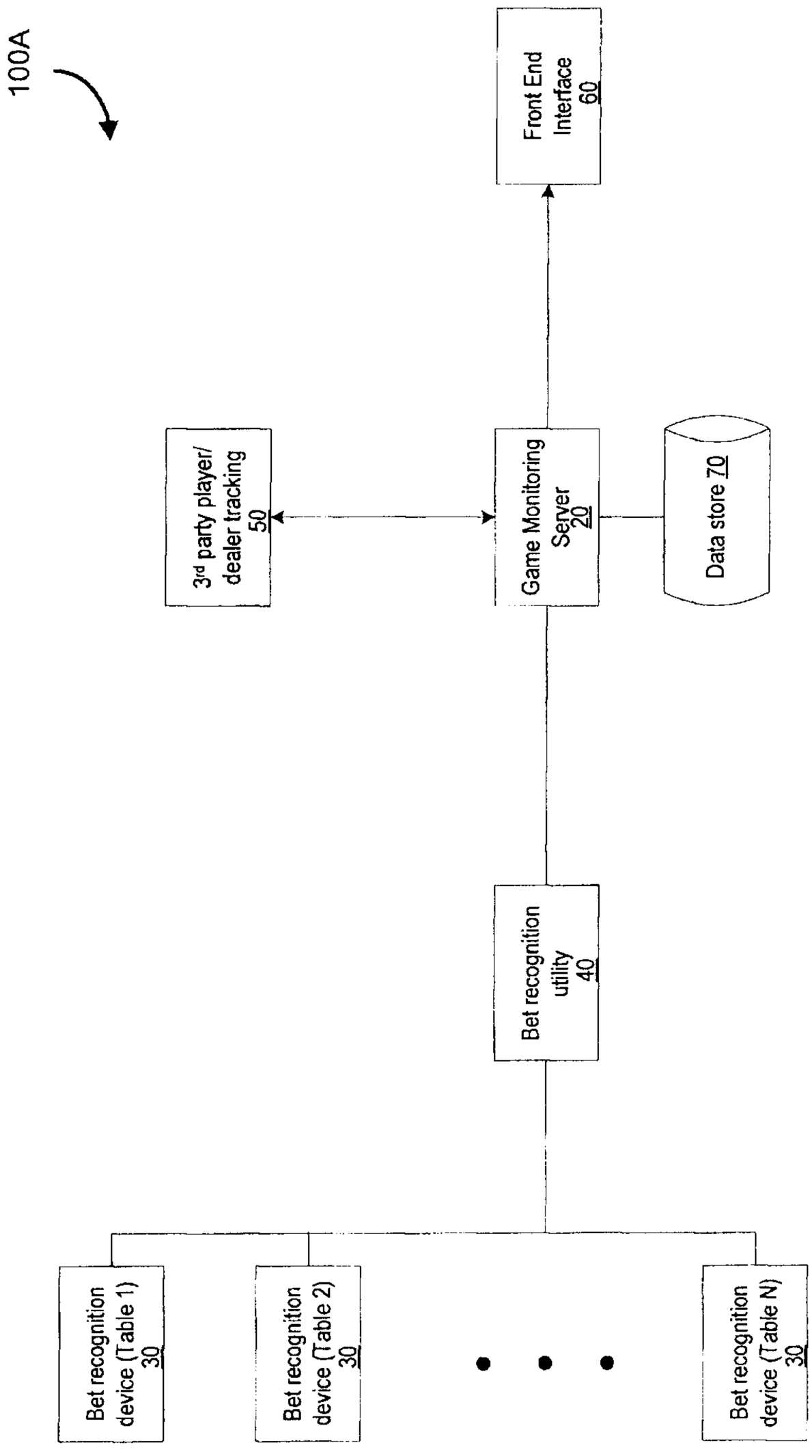

100A
Front End Interface 60
3rd party player/ dealer tracking 50
Game Monitoring Server 20
Data store 70
Bet recognition utility 40
Bet recognition device (Table 1) 30
Bet recognition device (Table 2) 30
Bet recognition device (Table N) 30

FIG. 1A

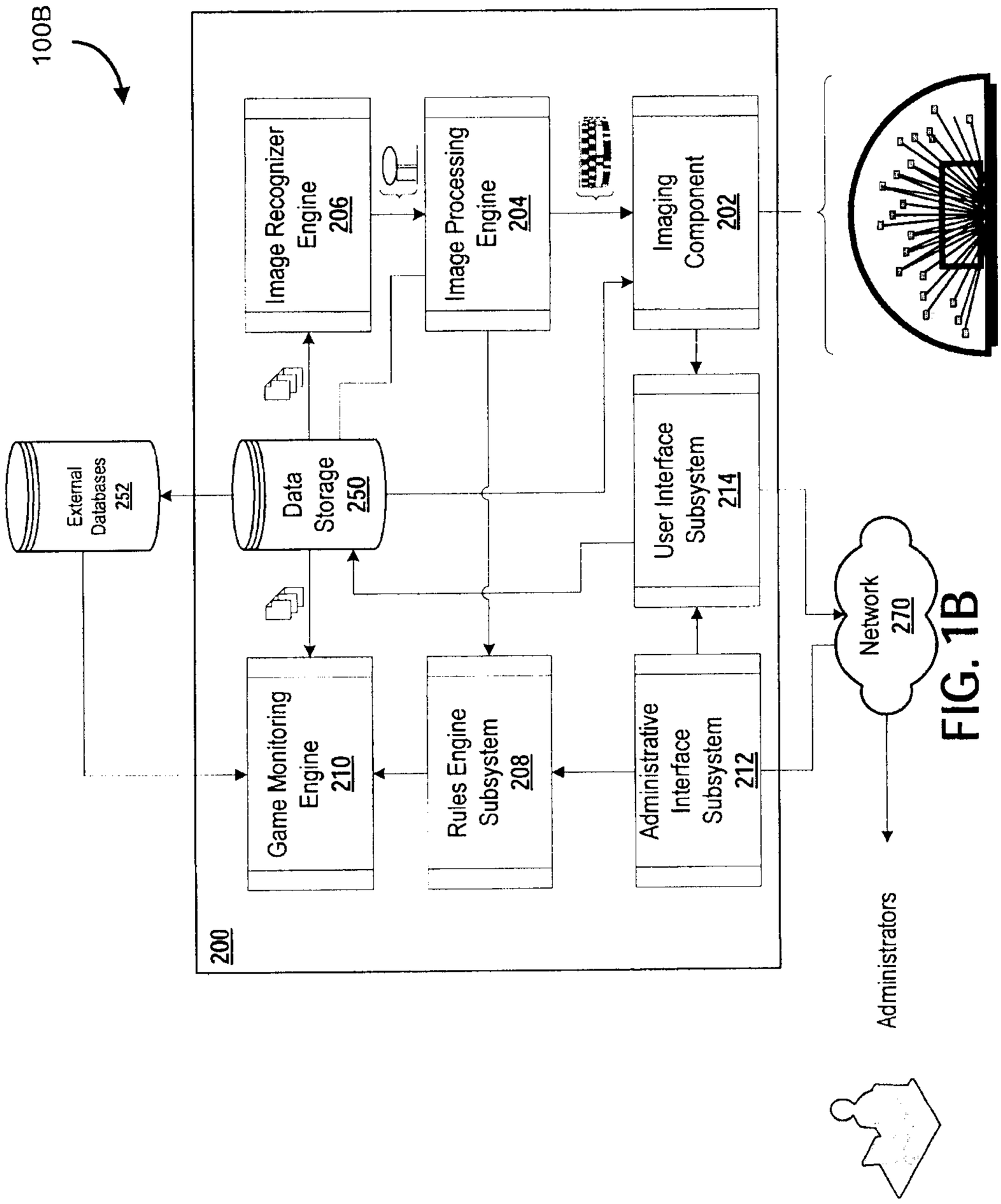

100B
Image Recognizer Engine 206
Image Processing Engine 204
Imaging Component 202
External Databases 252
Data Storage 250
User Interface Subsystem 214
Network 270
Game Monitoring Engine 210
Rules Engine Subsystem 208
Administrative Interface Subsystem 212
200
Administrators

FIG. 1B

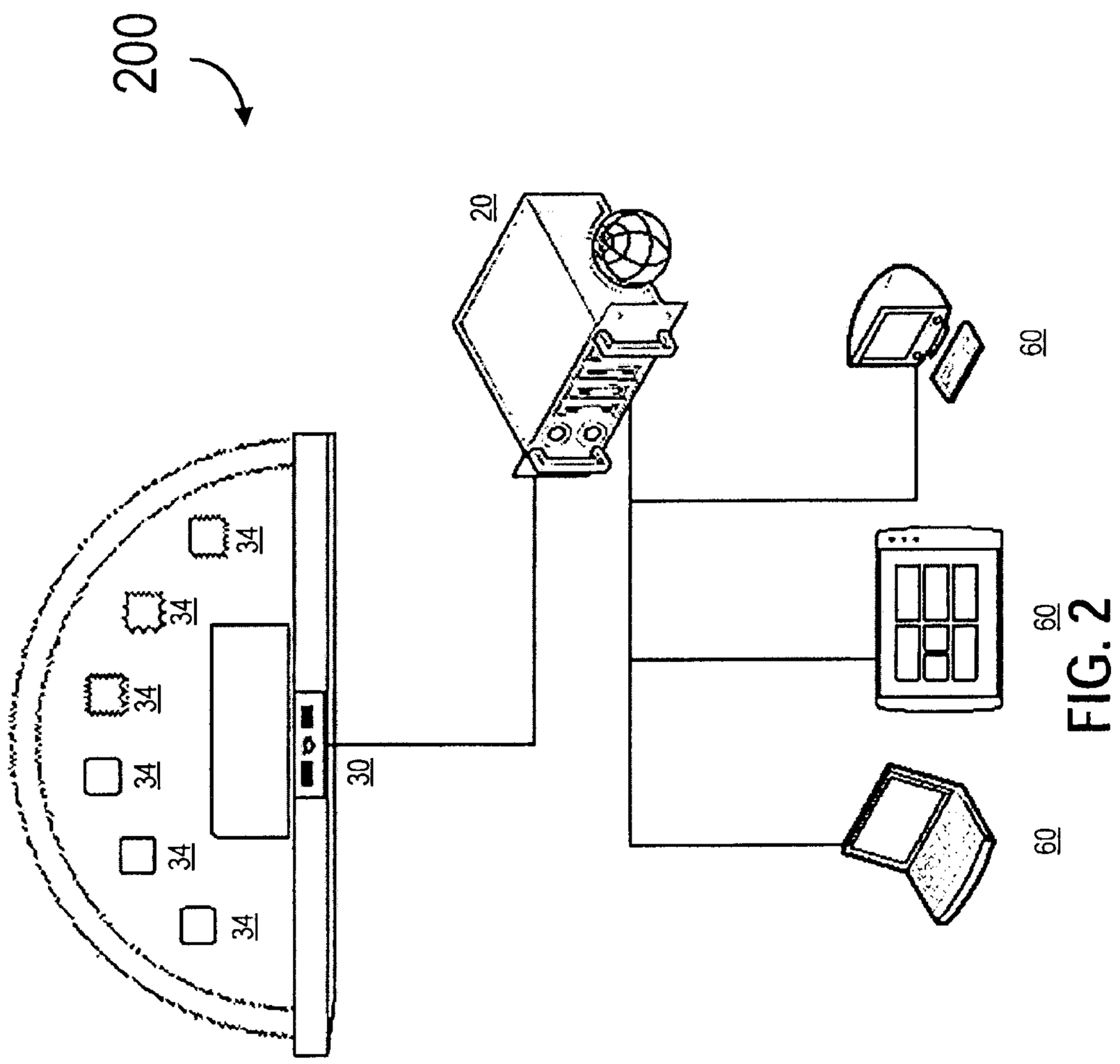


FIG. 2

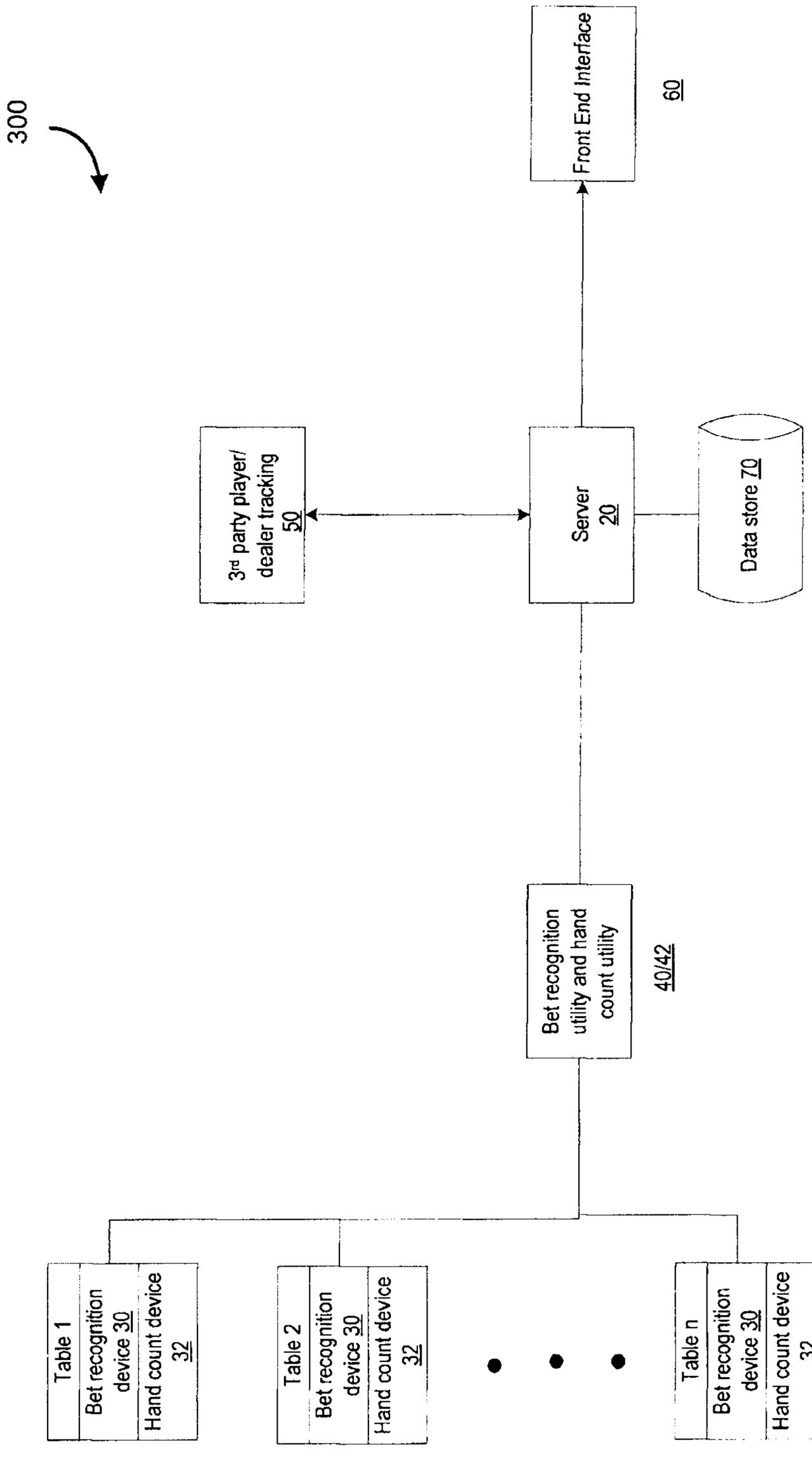

300
Front End Interface
60
3rd party player/ dealer tracking 50
Server 20
Data store 70
Bet recognition utility and hand count utility
40/42
Table 1
Bet recognition device 30
Hand count device 32
Table 2
Bet recognition device 30
Hand count device 32
Table n
Bet recognition device 30
Hand count device 32

FIG. 3

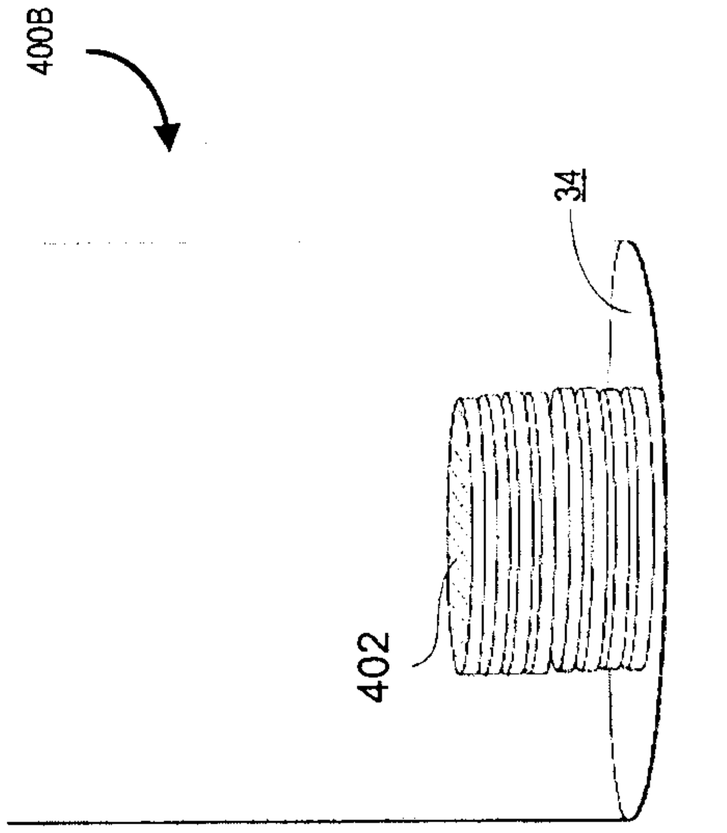


FIG. 4A

FIG. 4B

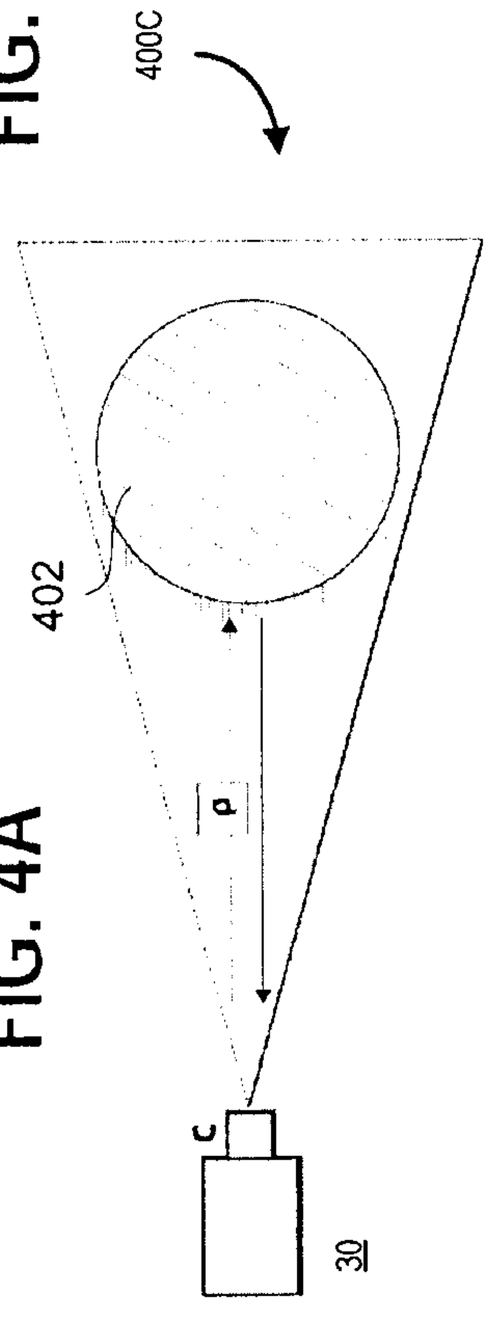


FIG. 4C

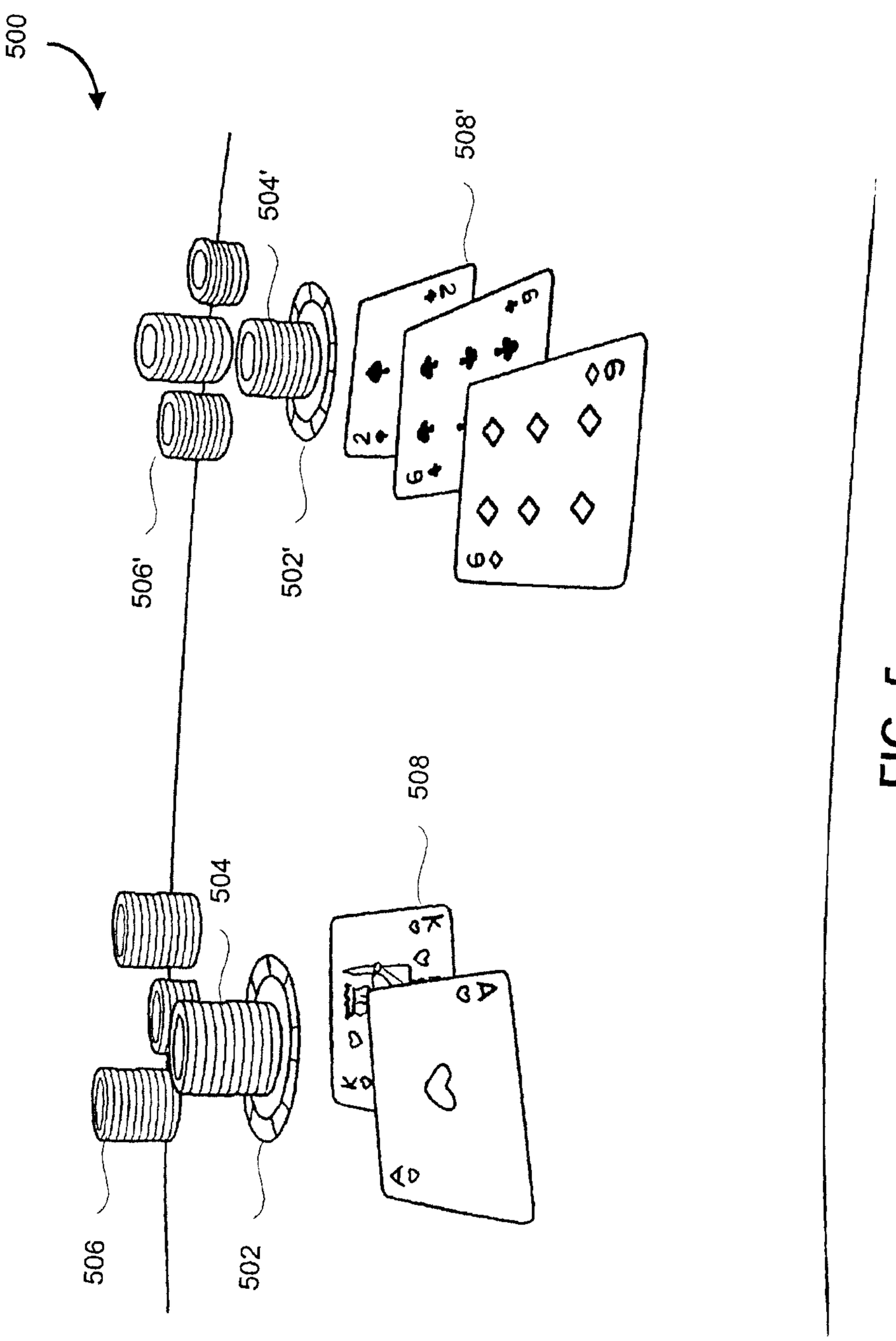


FIG. 5

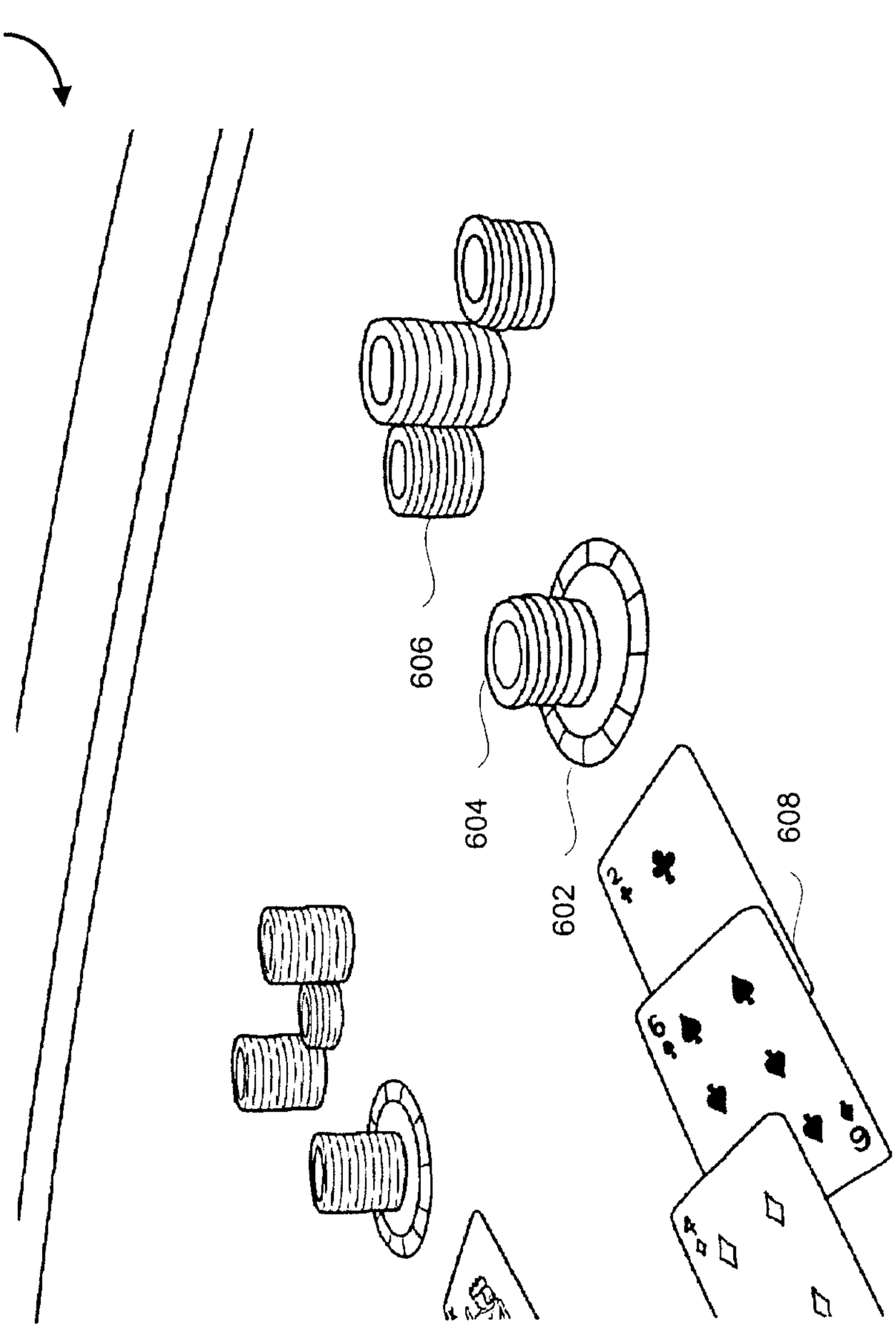


FIG. 6

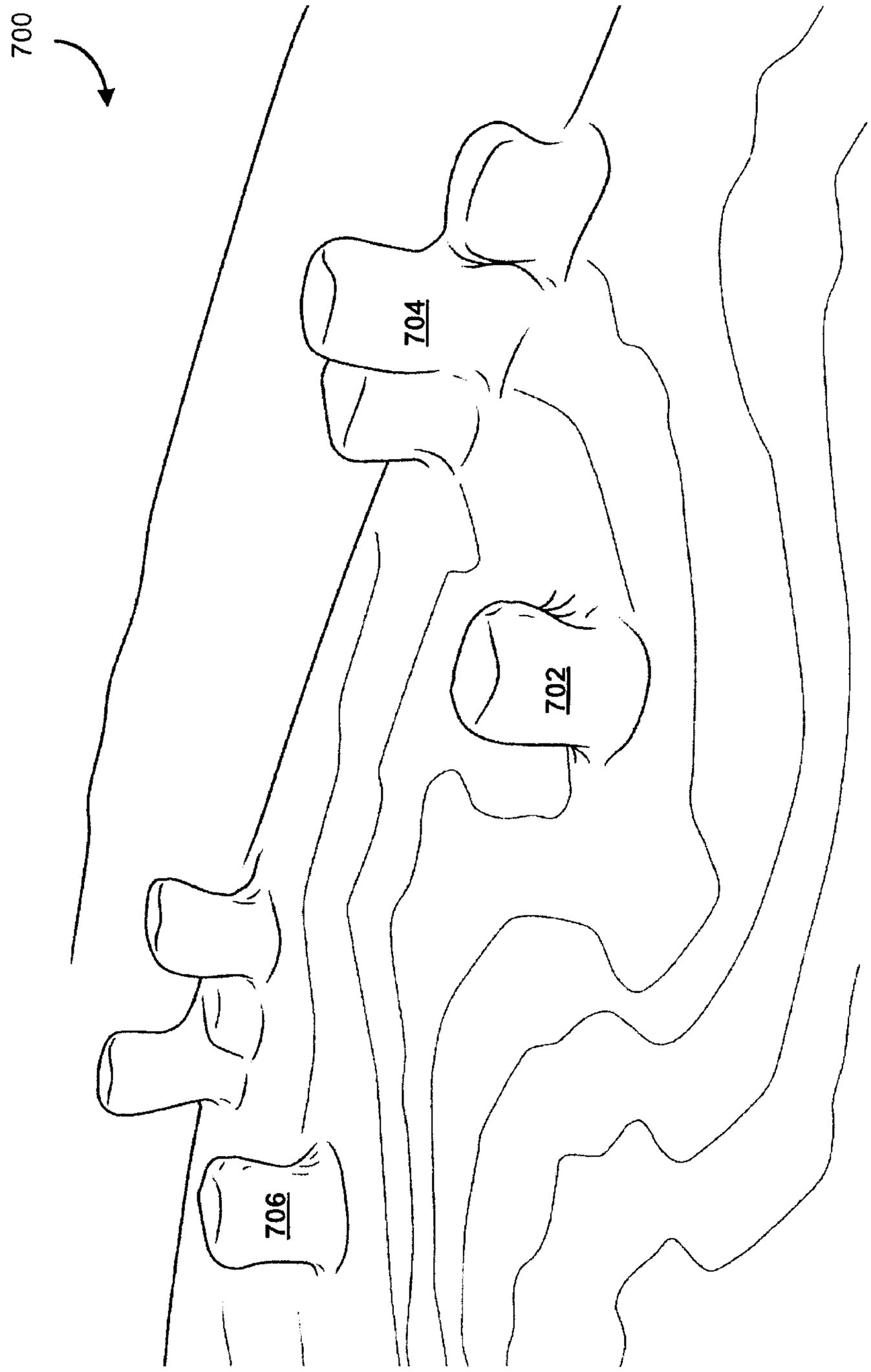


FIG. 7

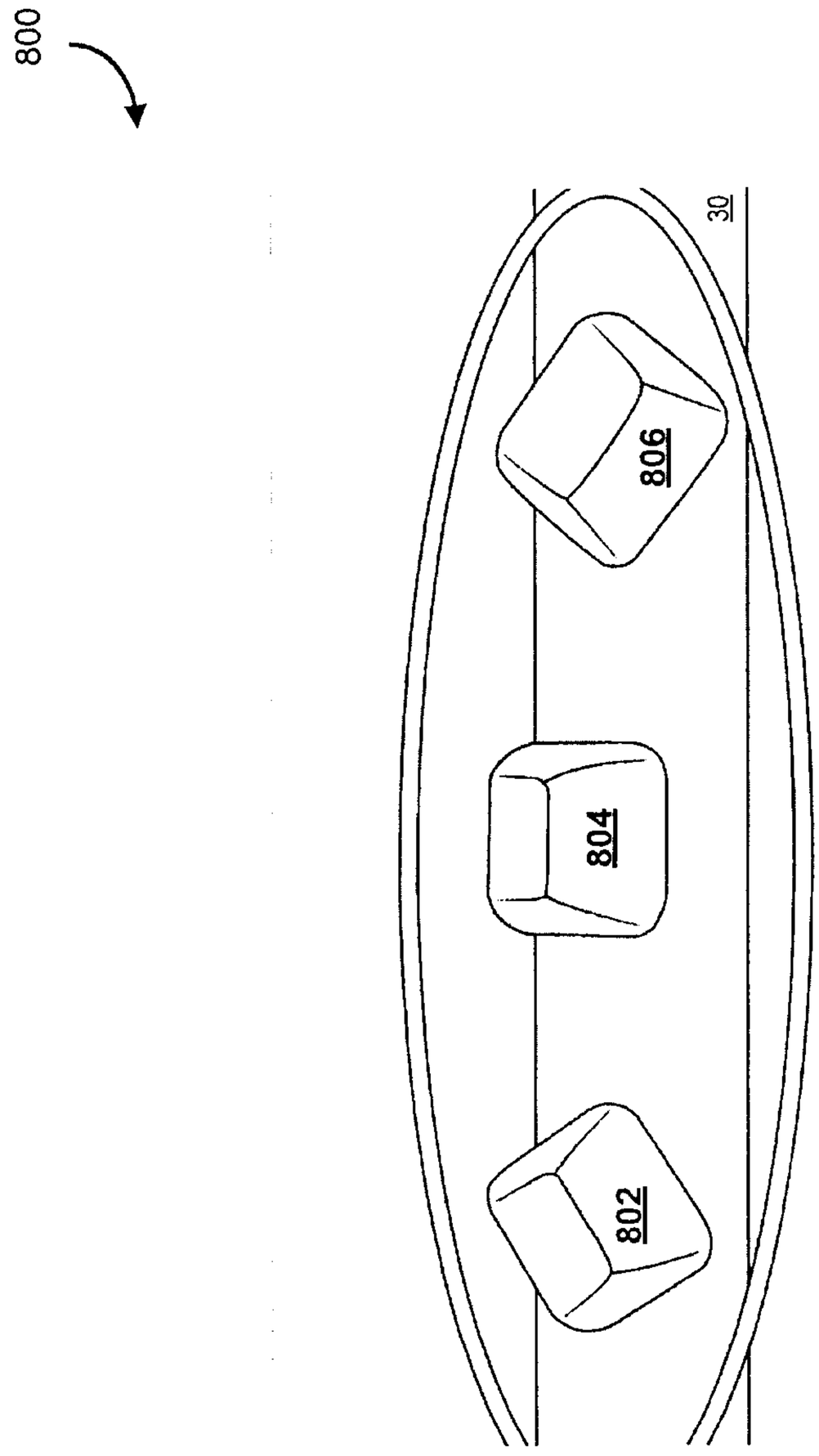


FIG. 8

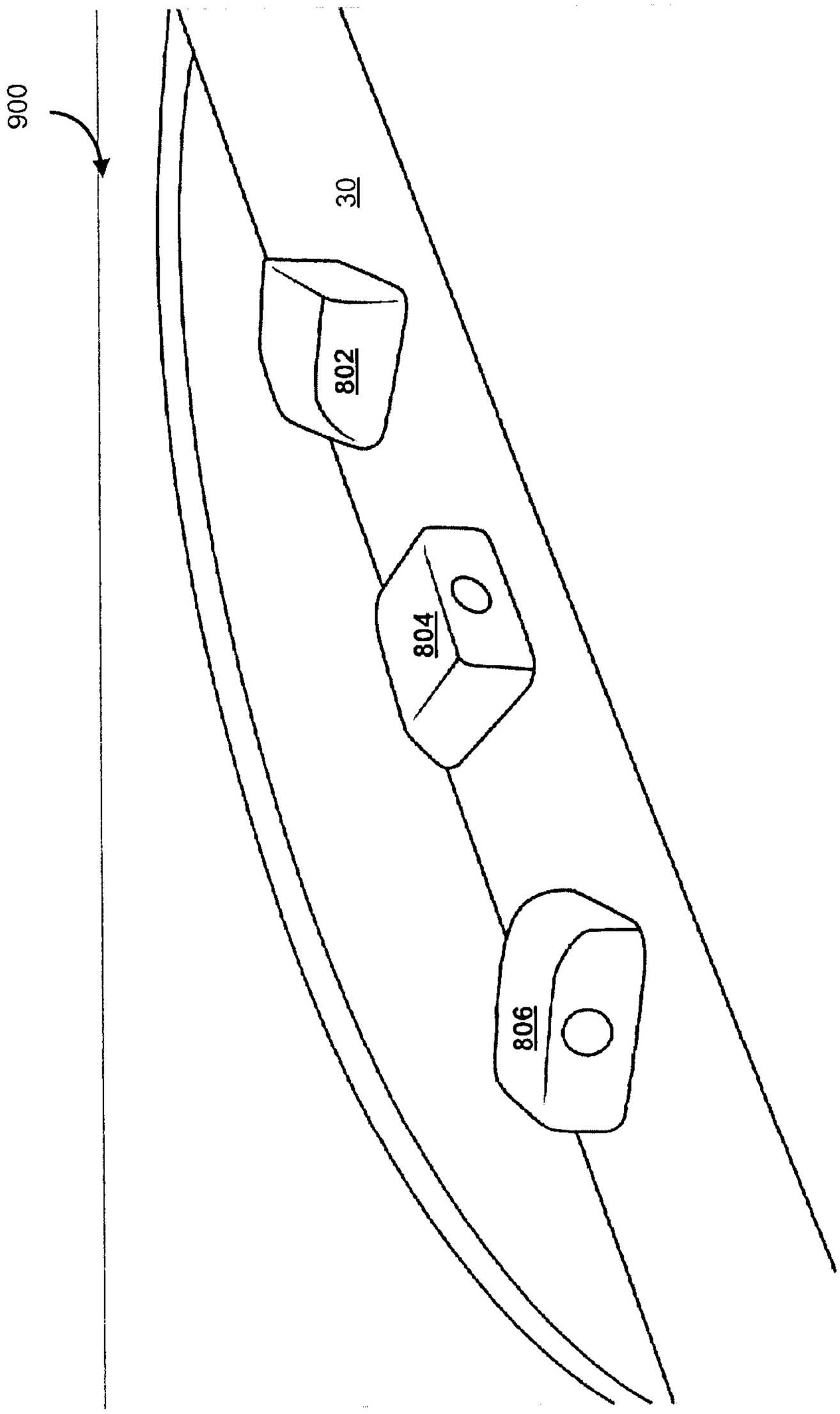


FIG. 9

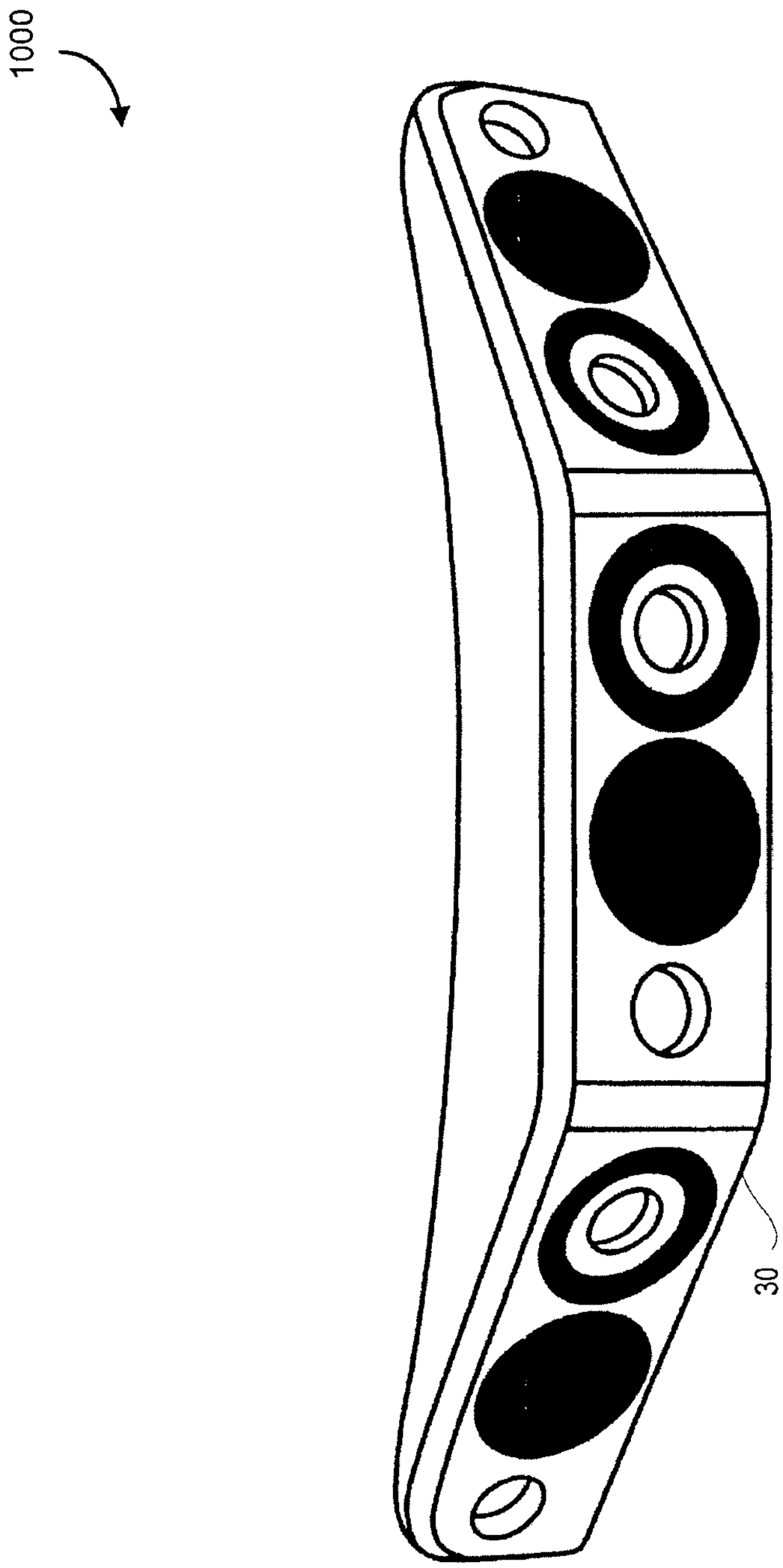


FIG. 10

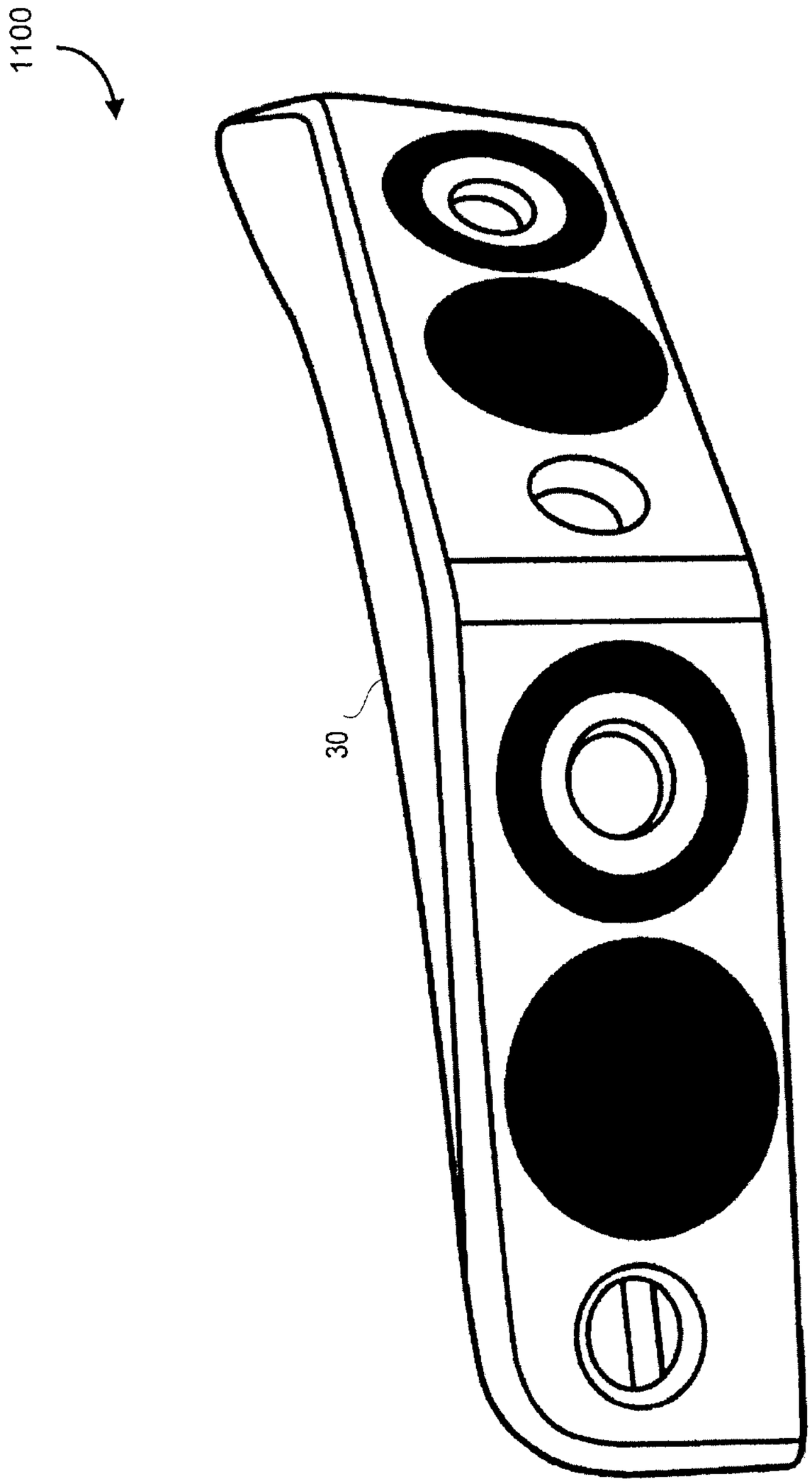


FIG. 11

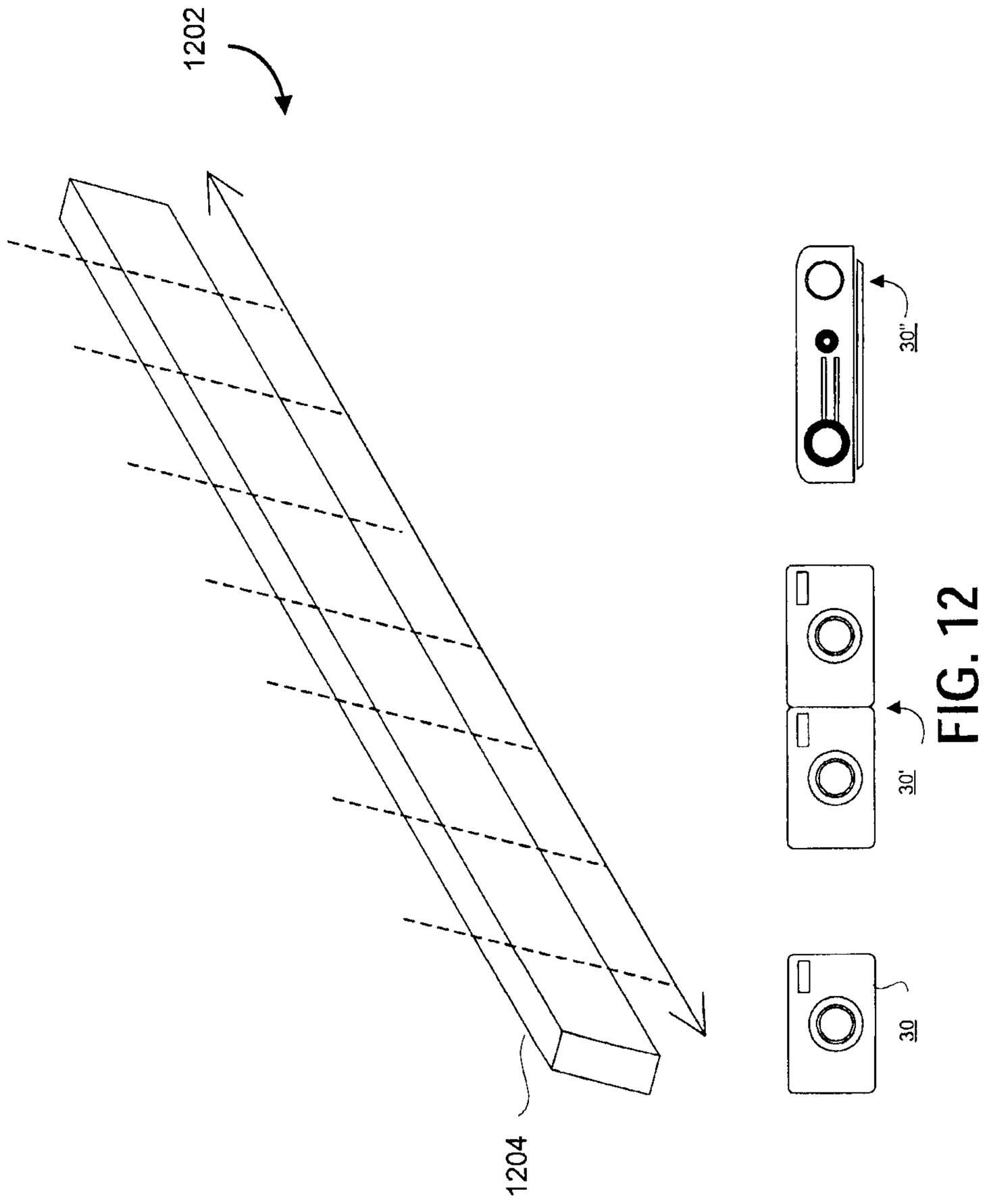


FIG. 12

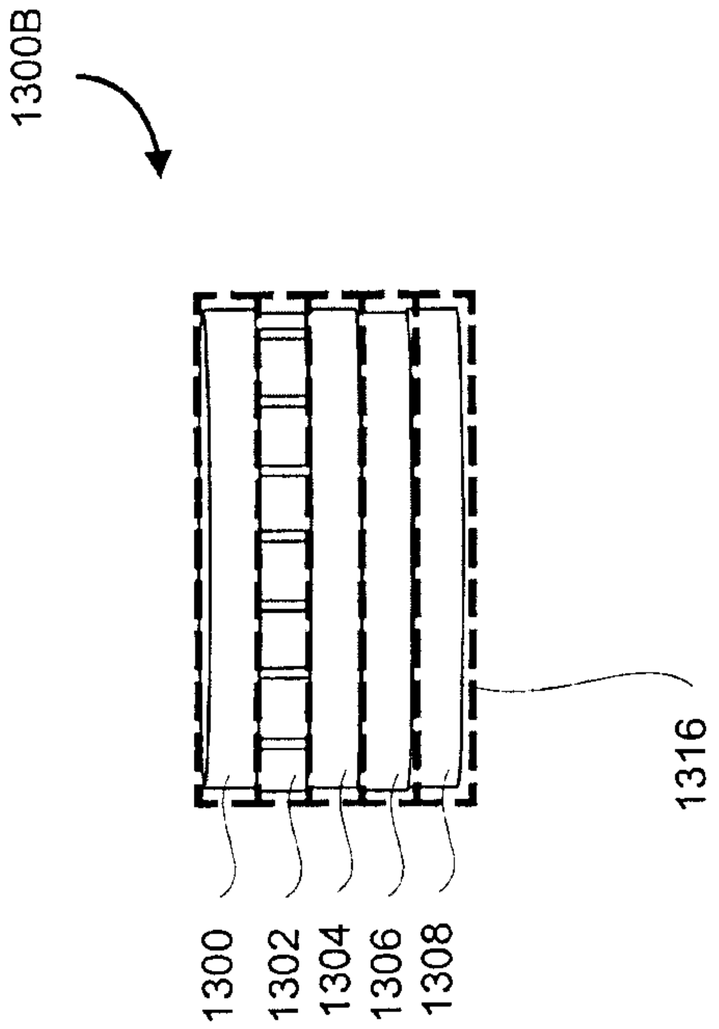


FIG. 13B

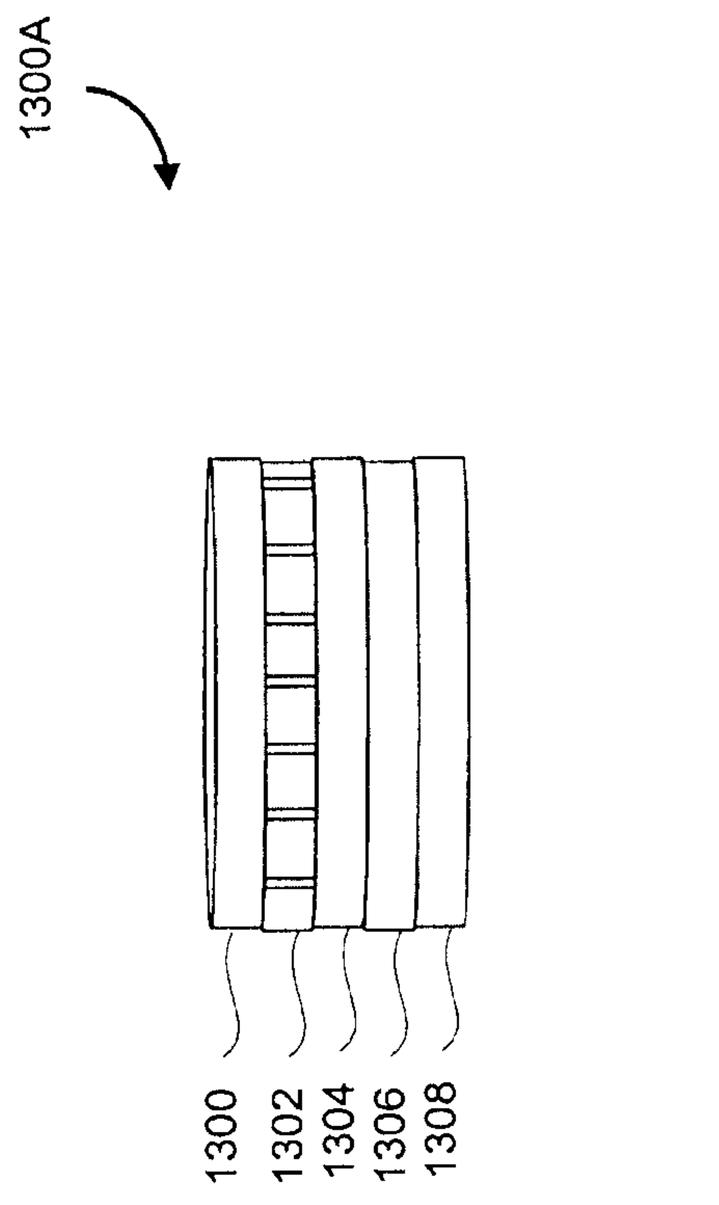


FIG. 13A

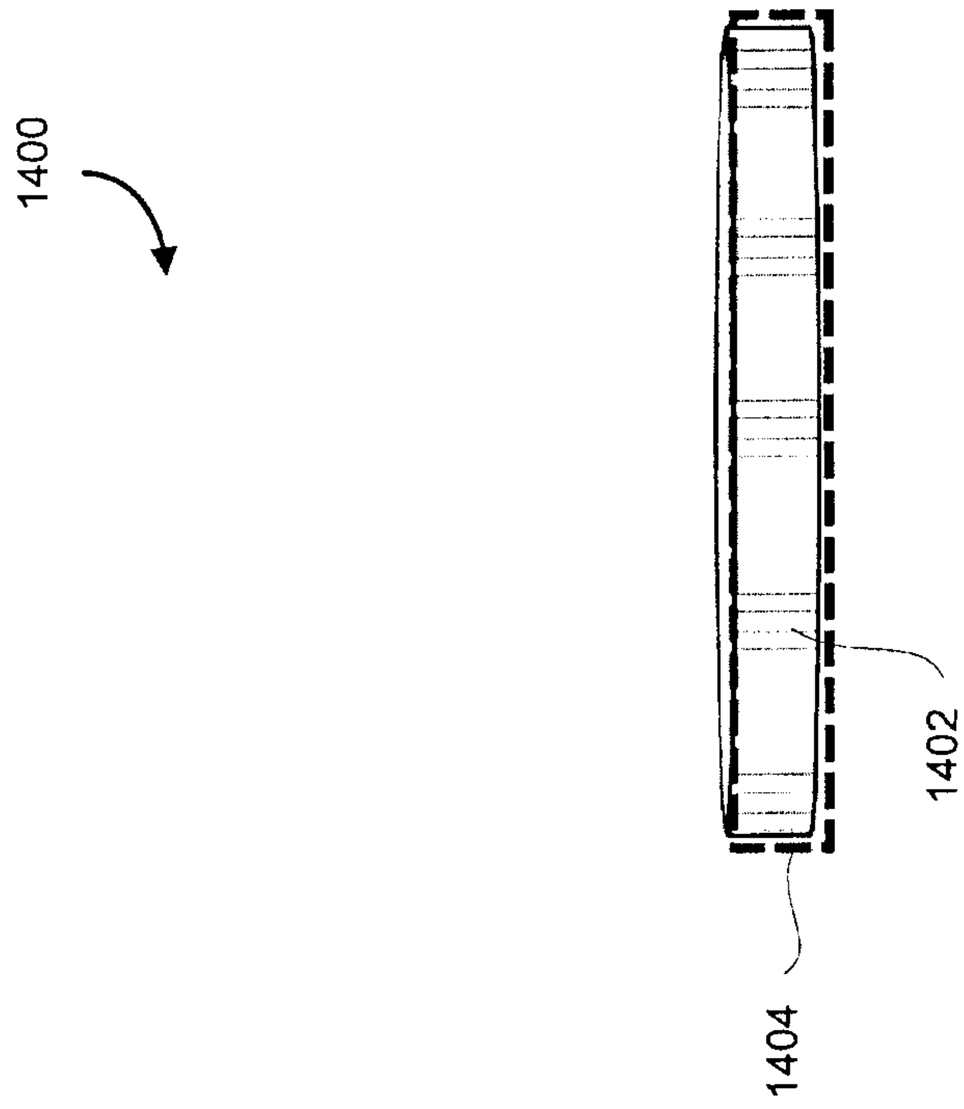
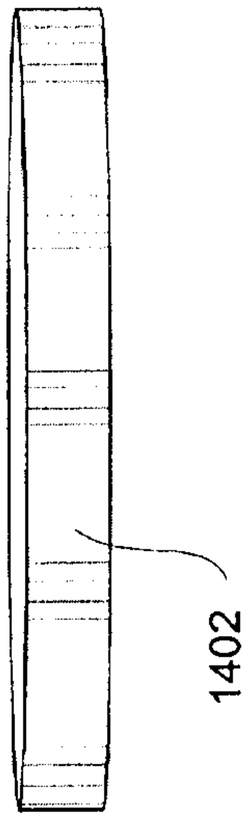


FIG. 14



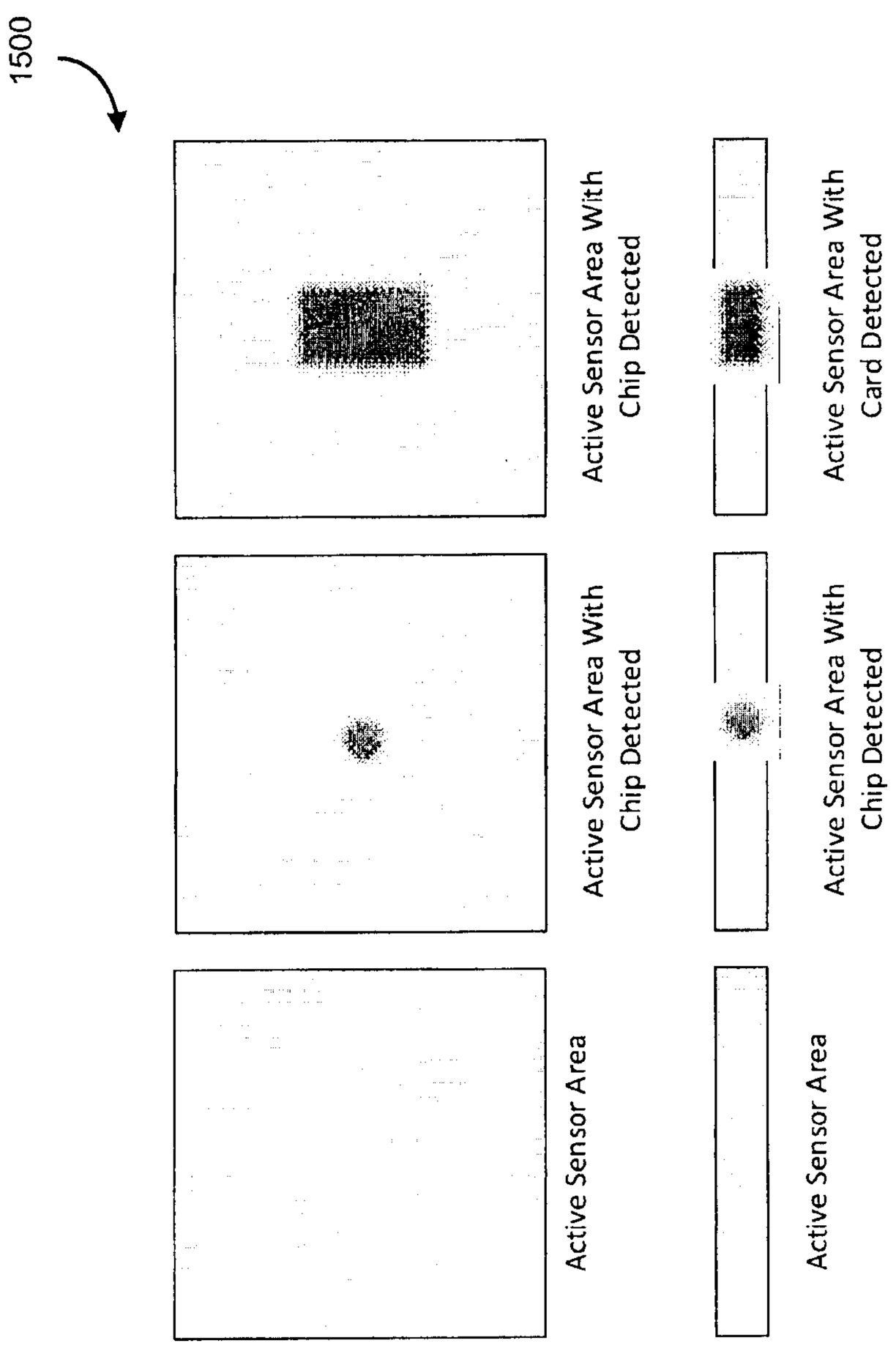

1500
Active Sensor Area With Chip Detected
Active Sensor Area With Chip Detected
Active Sensor Area With Chip Detected
Active Sensor Area With Card Detected
Active Sensor Area
Active Sensor Area

FIG. 15

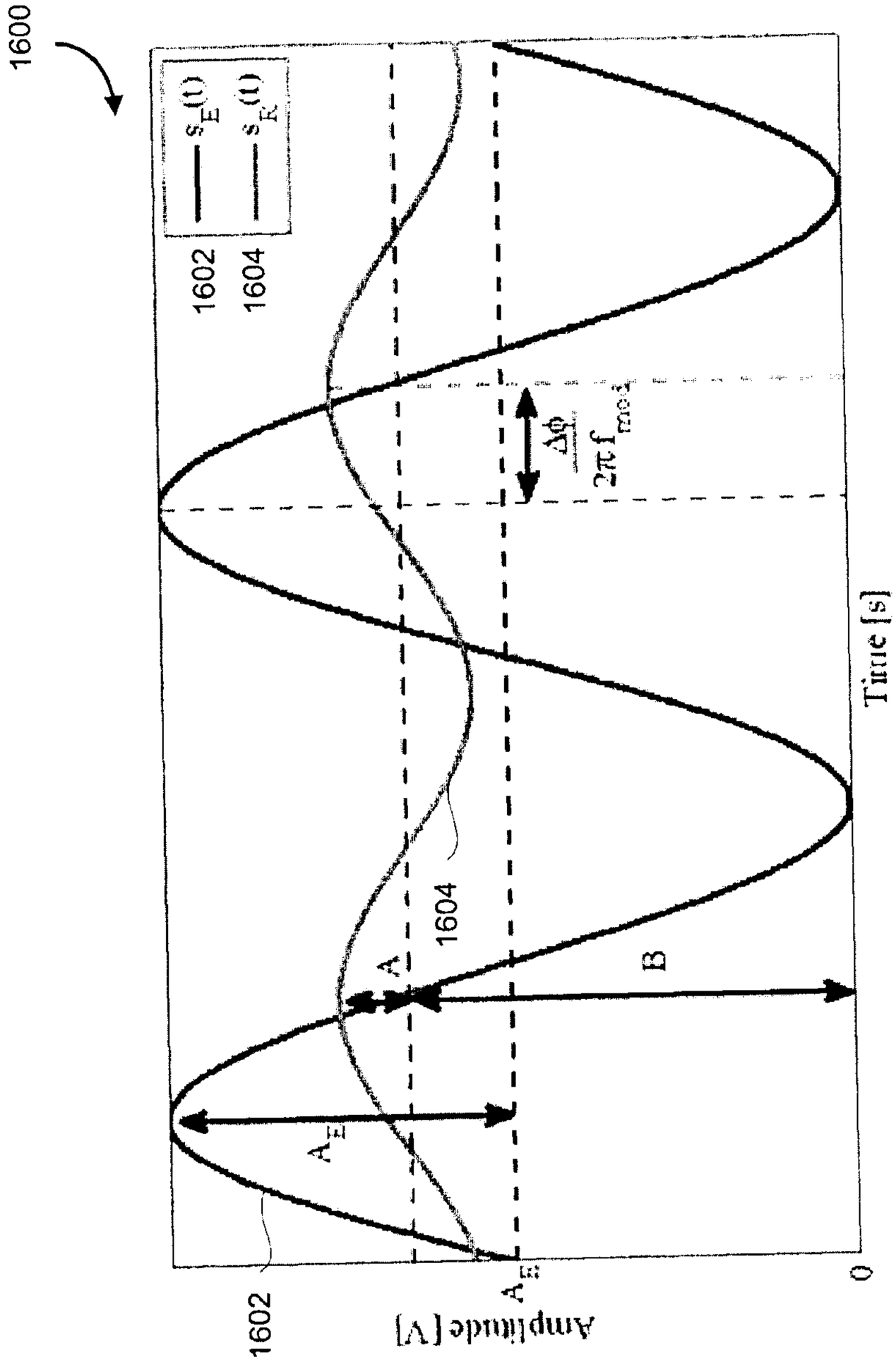

1600
$s_E(t)$
$s_R(t)$
1602
1604
$\frac{\Delta\phi}{2\pi f_{mod}}$
Time [s]
A
B
A_E
A_R
0
1602
1604
Amplitude [V]

FIG. 16

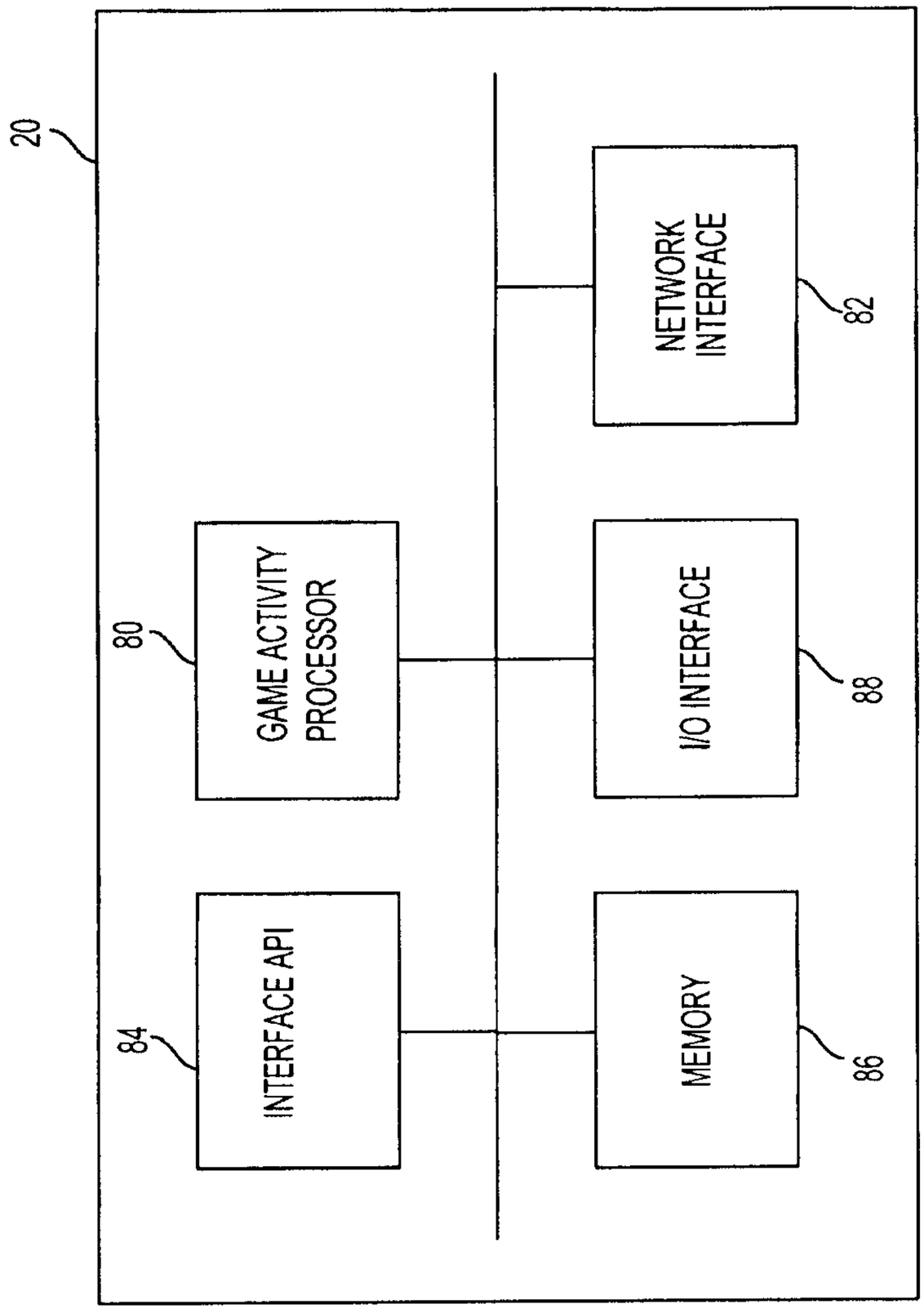

20
80
GAME ACTIVITY PROCESSOR
NETWORK INTERFACE
82
I/O INTERFACE
88
84
INTERFACE API
MEMORY
86

FIG. 17

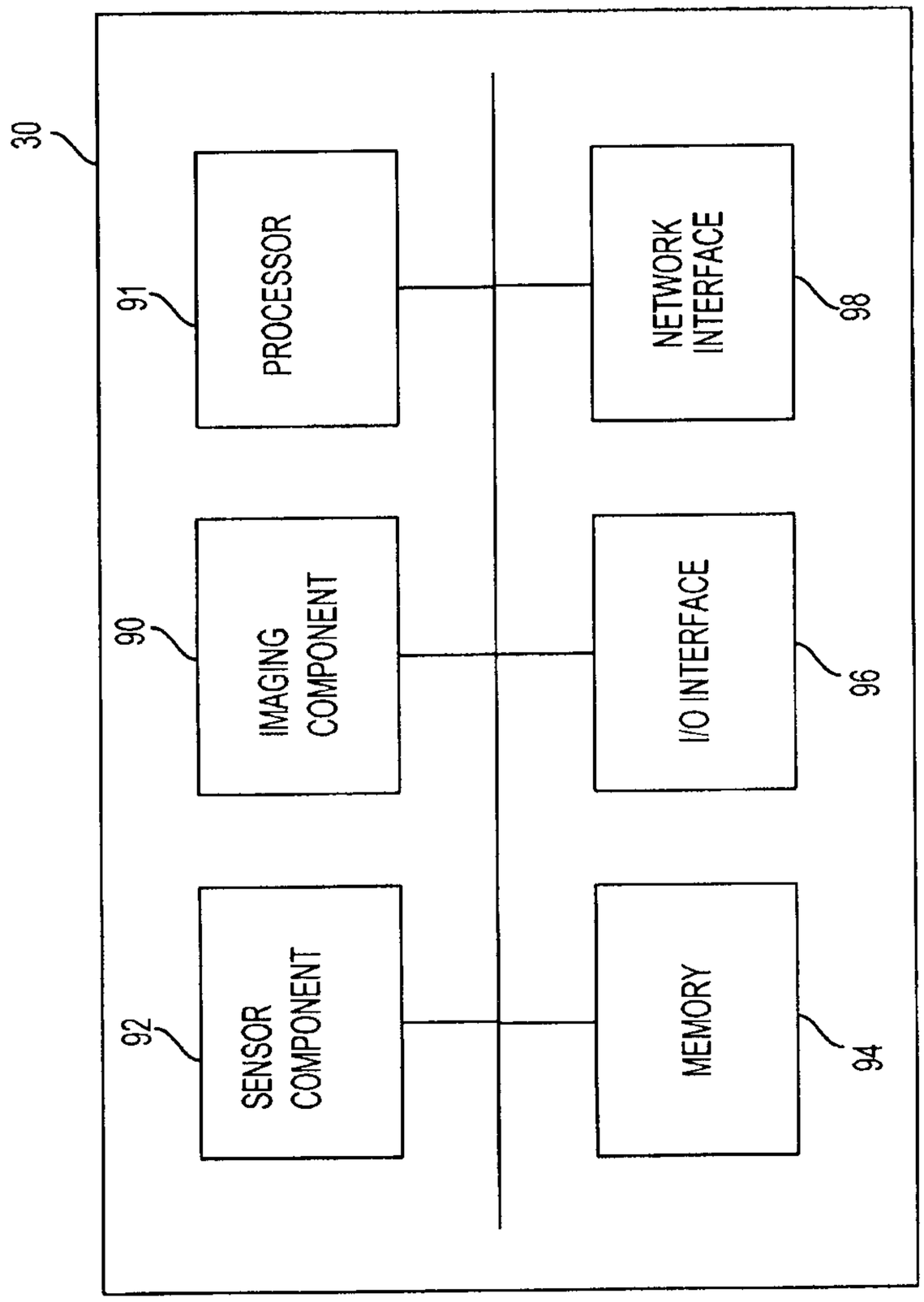

30
PROCESSOR
91
NETWORK INTERFACE
98
IMAGING COMPONENT
90
I/O INTERFACE
96
SENSOR COMPONENT
92
MEMORY
94

FIG. 18

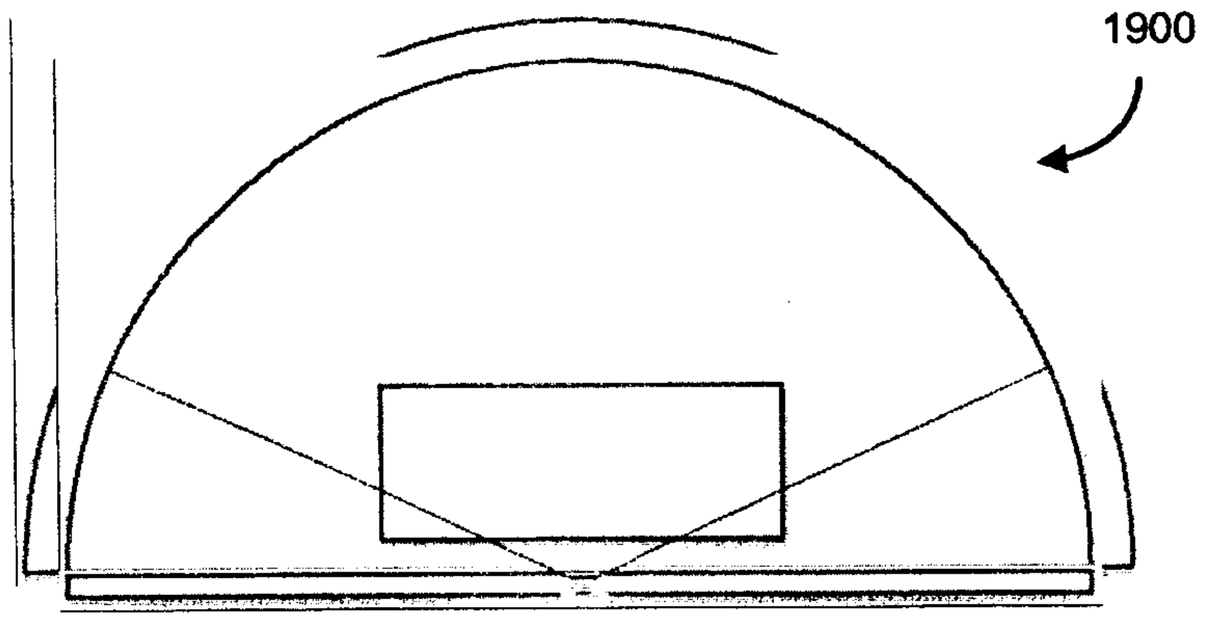


FIG. 19

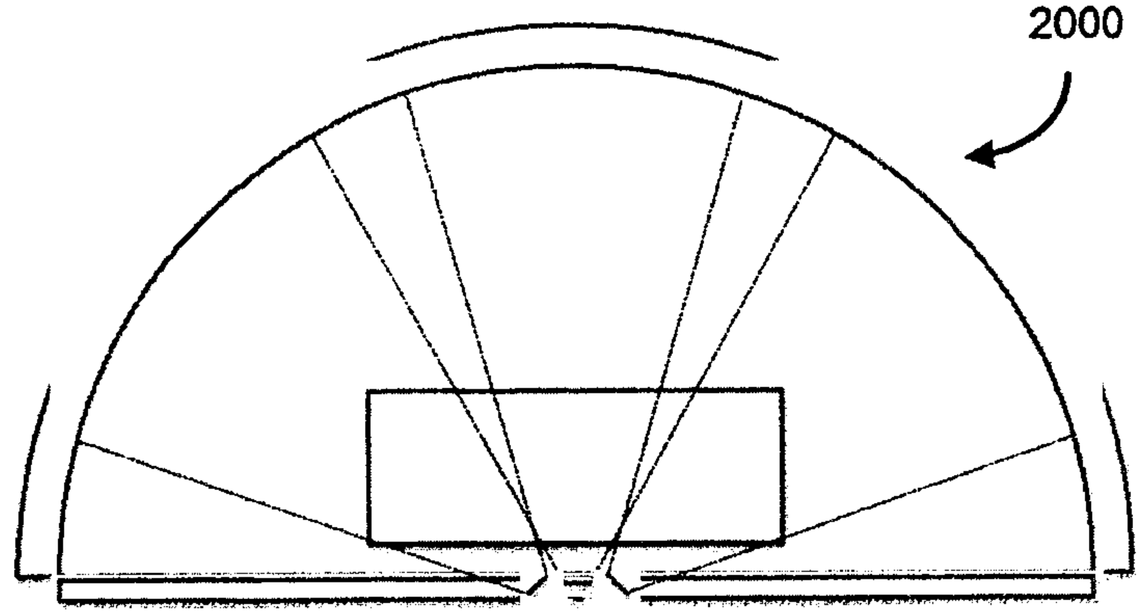


FIG. 20

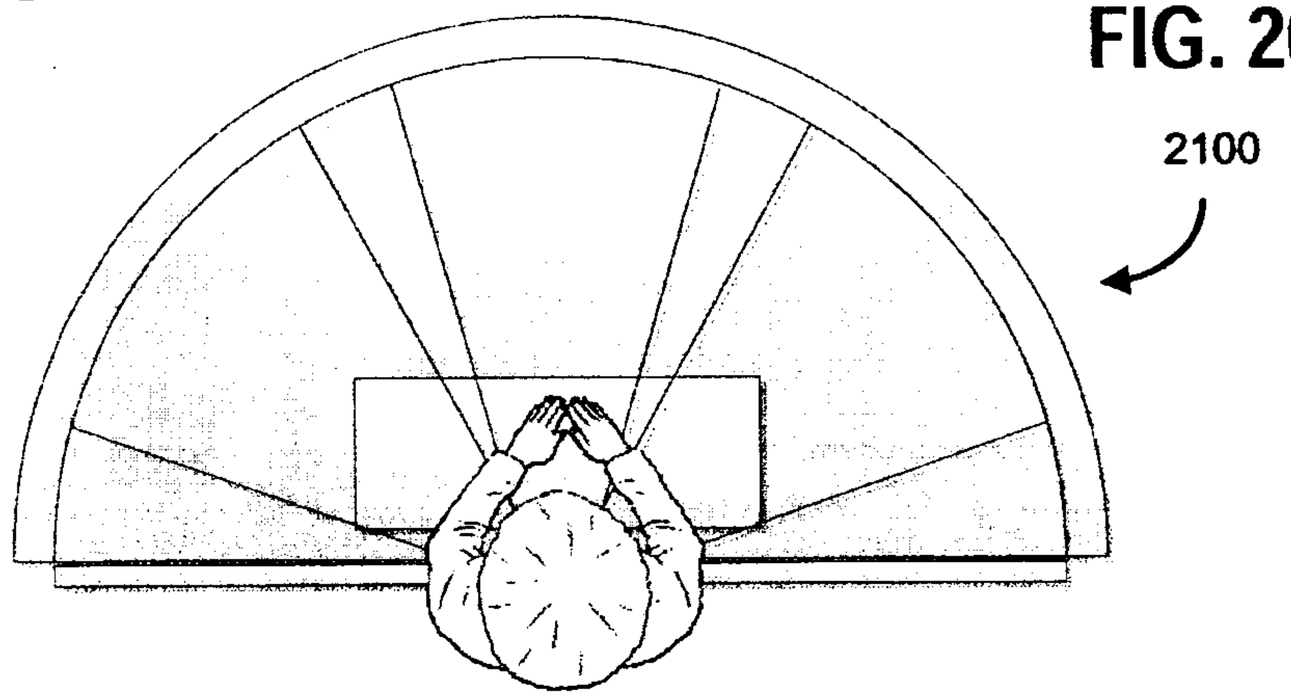


FIG. 21

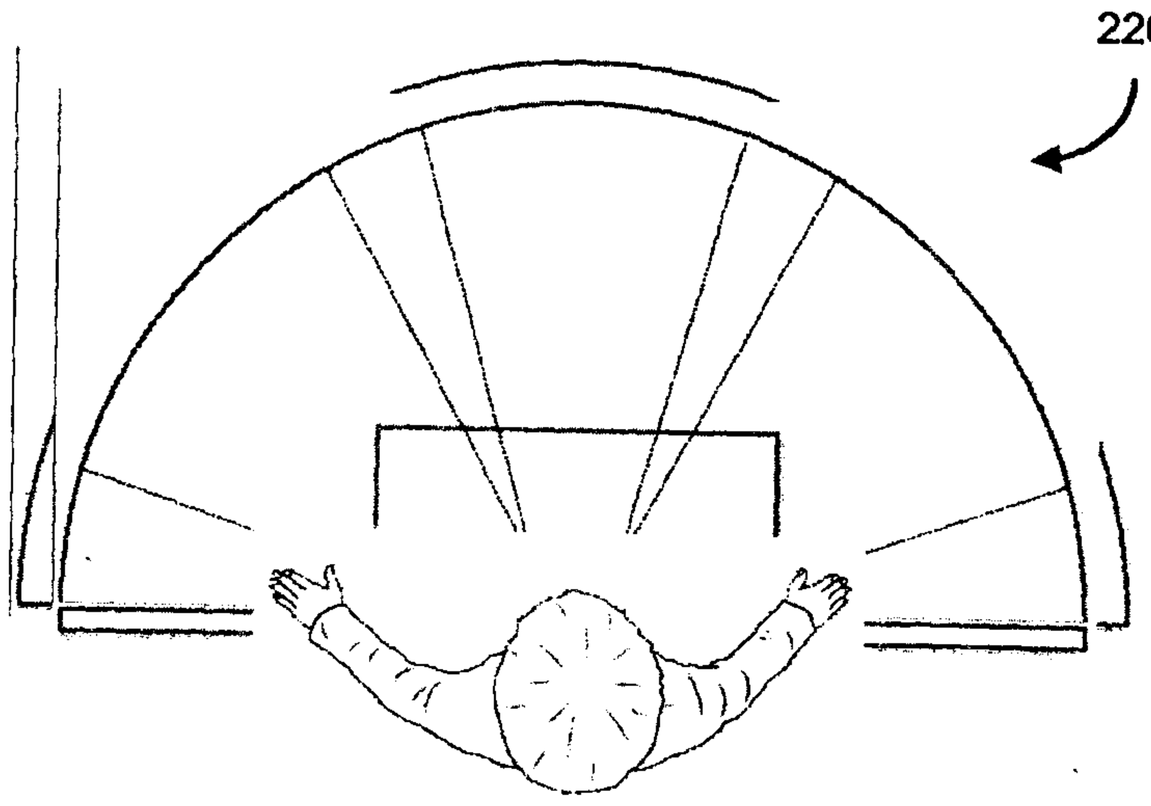


FIG. 22

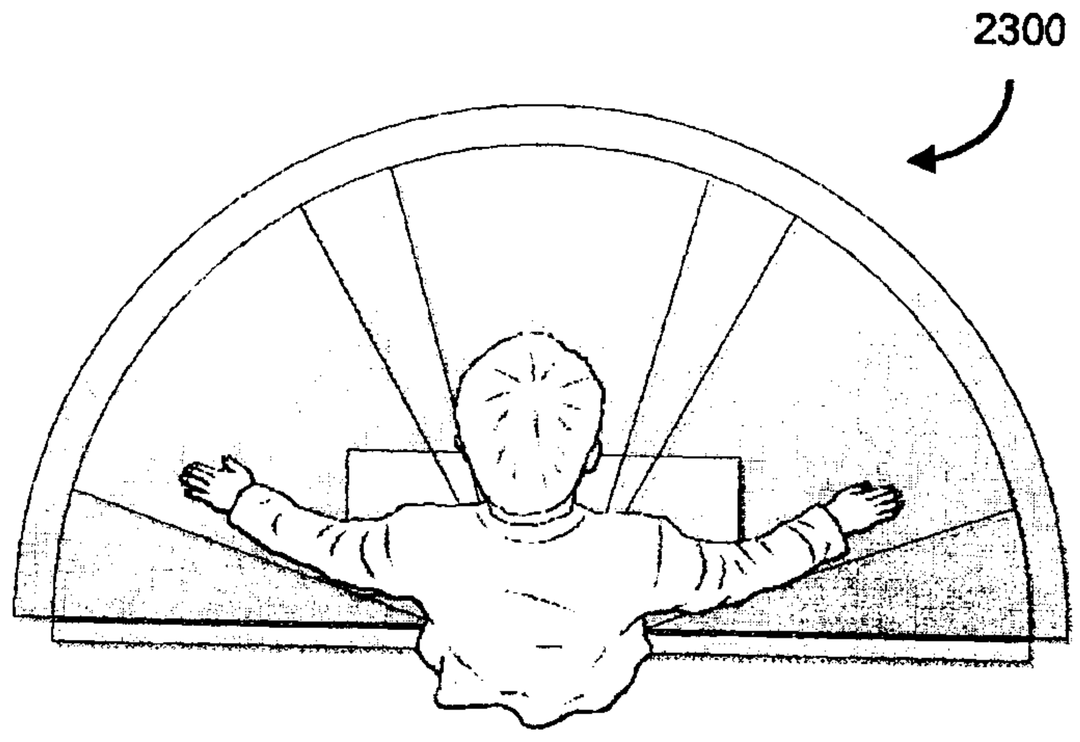


FIG. 23

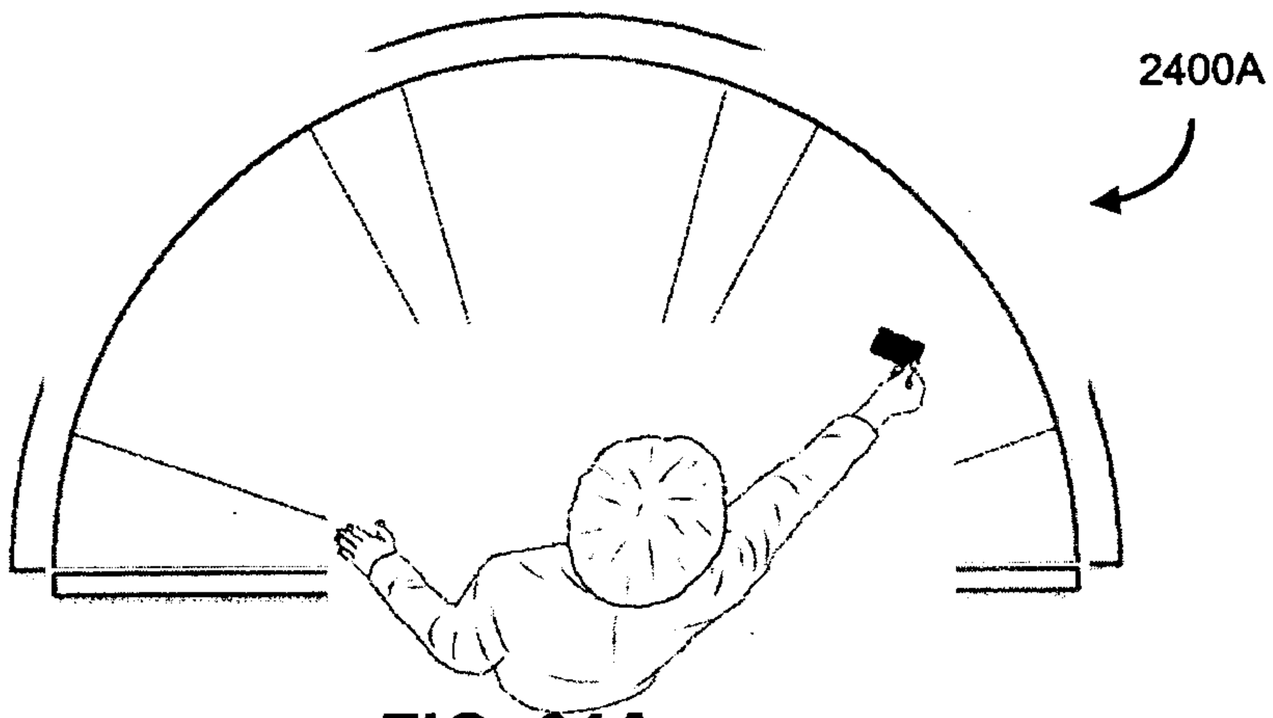


FIG. 24A

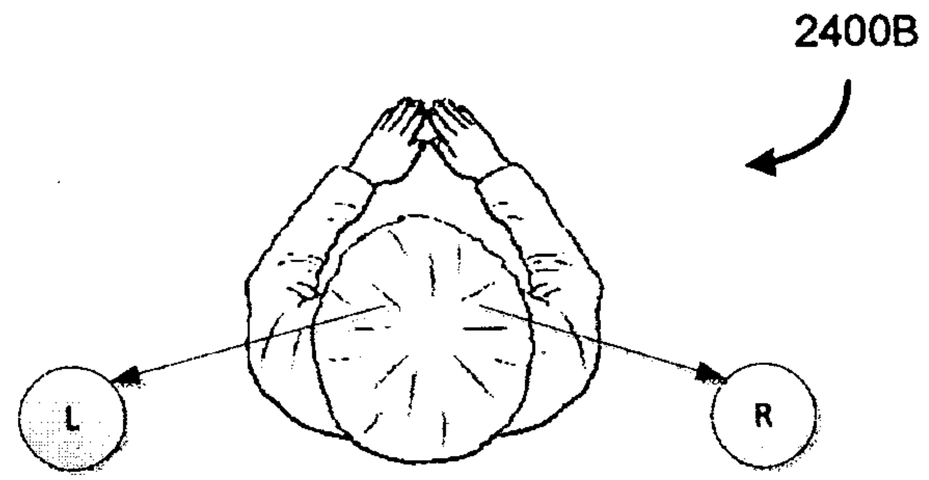


FIG. 24B

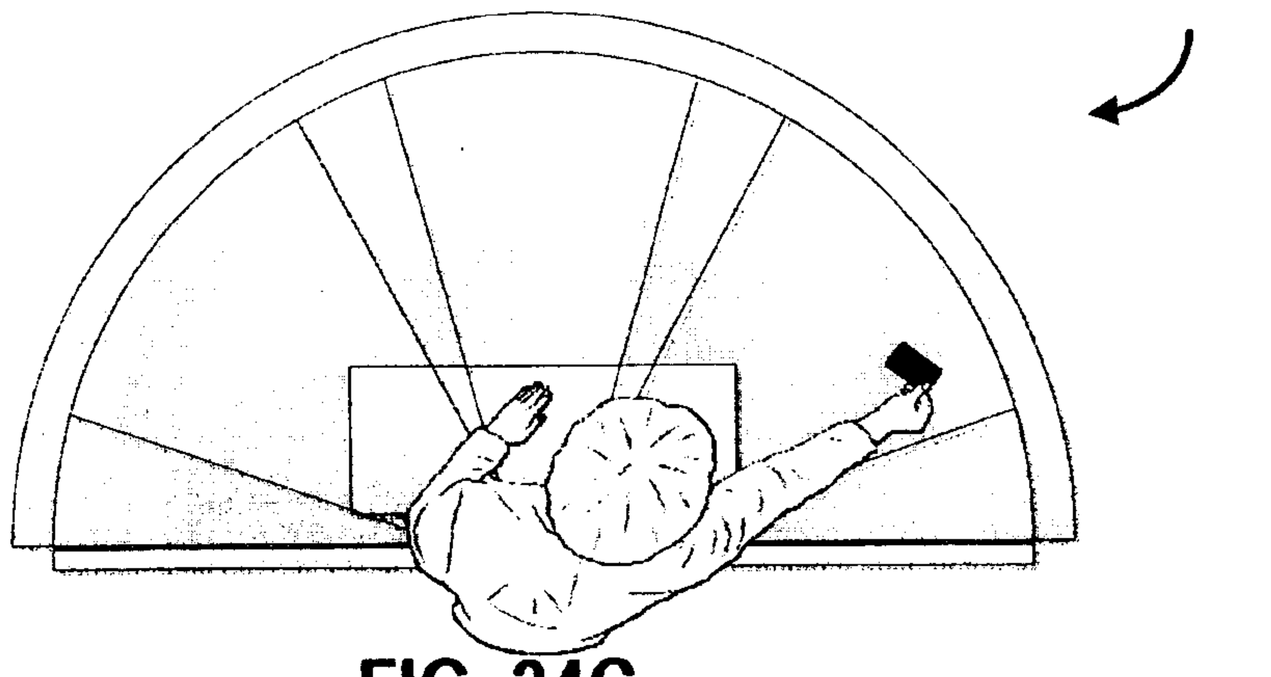


FIG. 24C

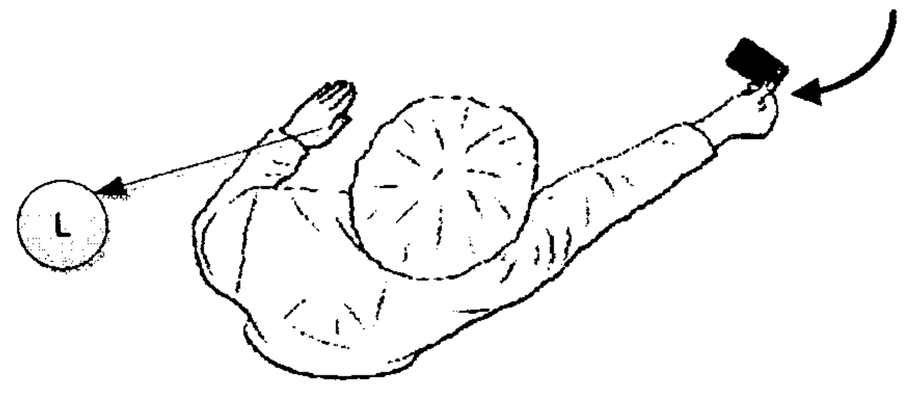


FIG. 24D

CA 2970692 2017-06-15

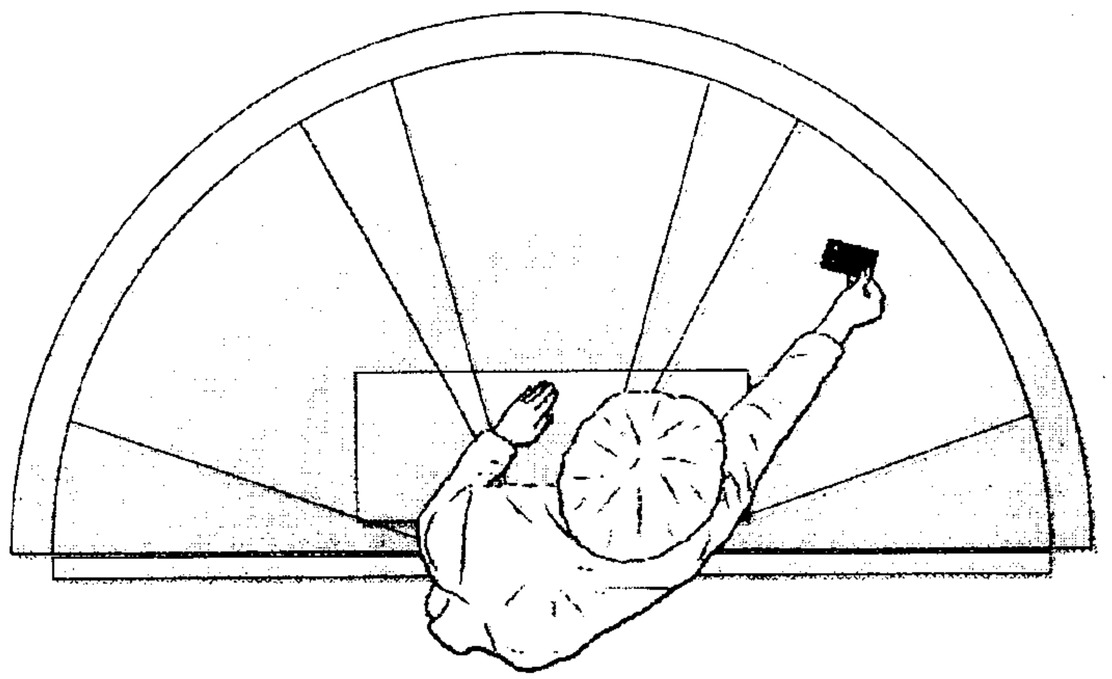


FIG. 25A

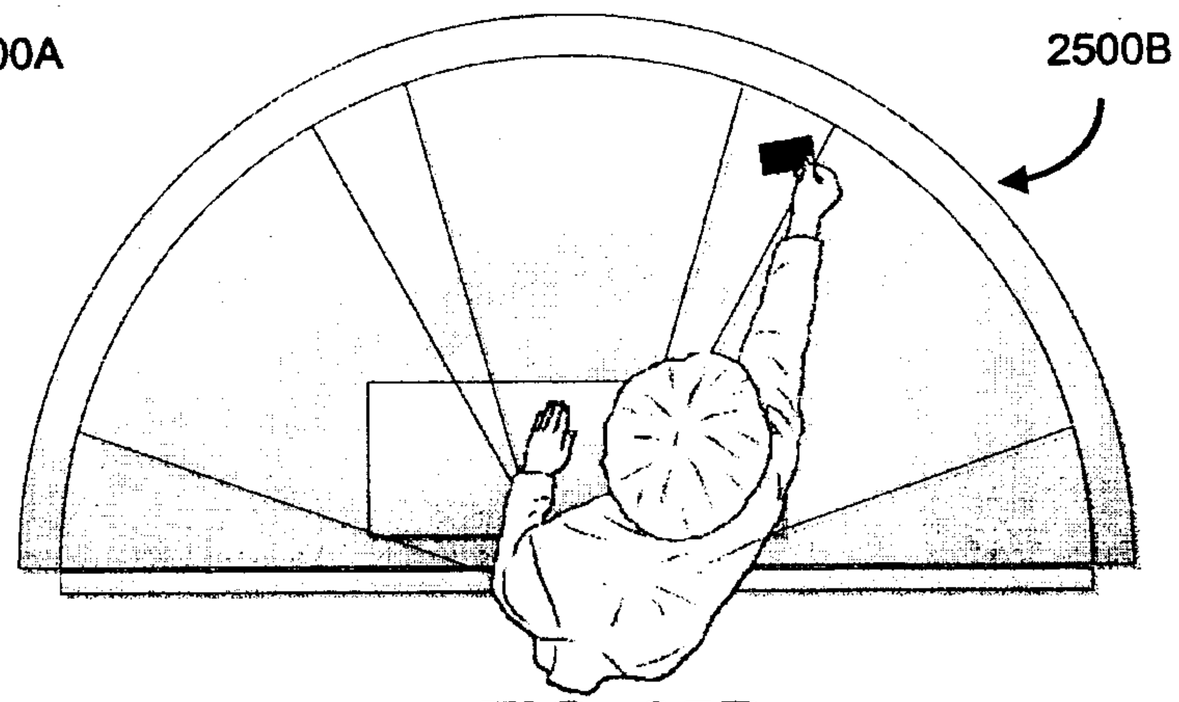


FIG. 25B

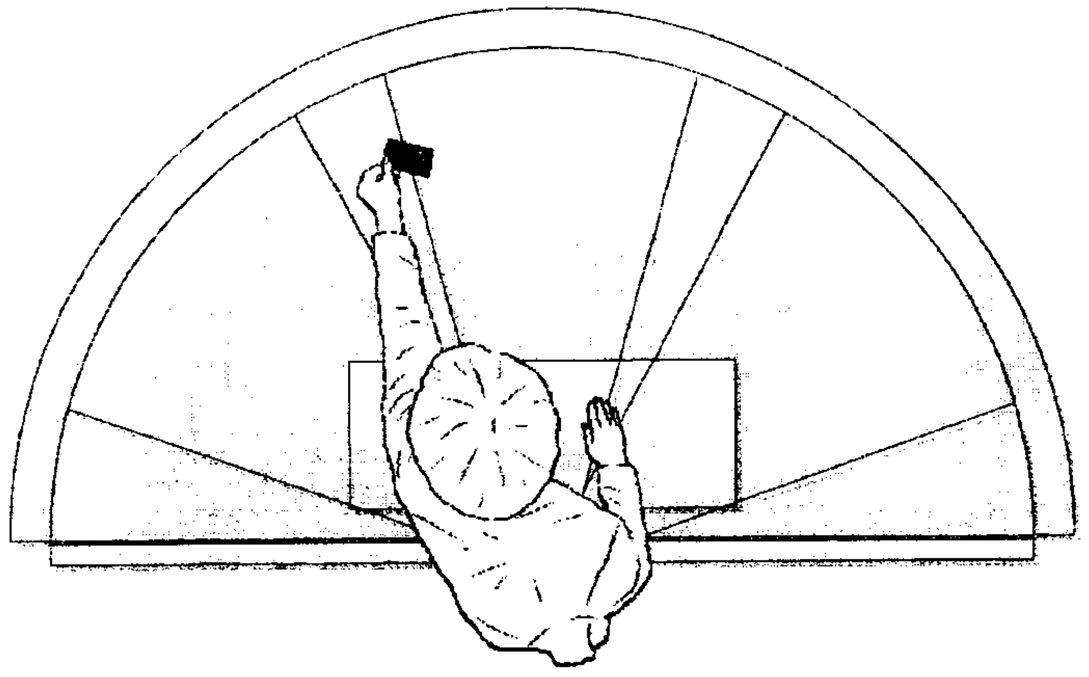


FIG. 25C

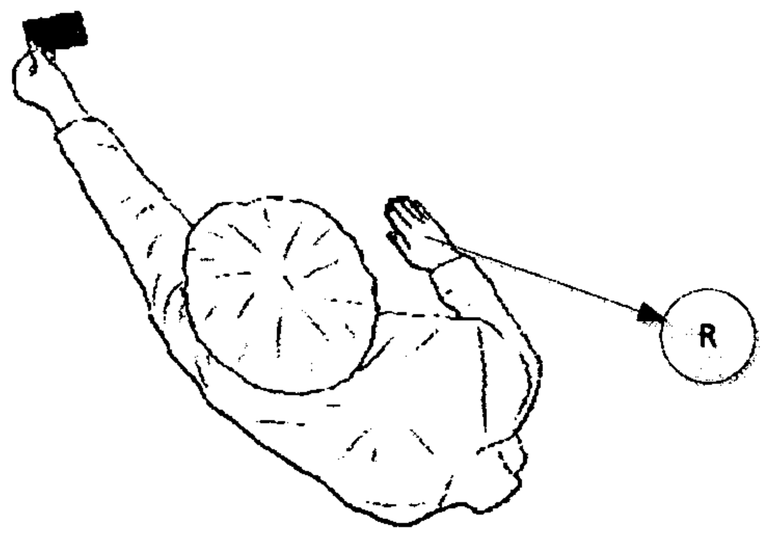


FIG. 25D

2500E

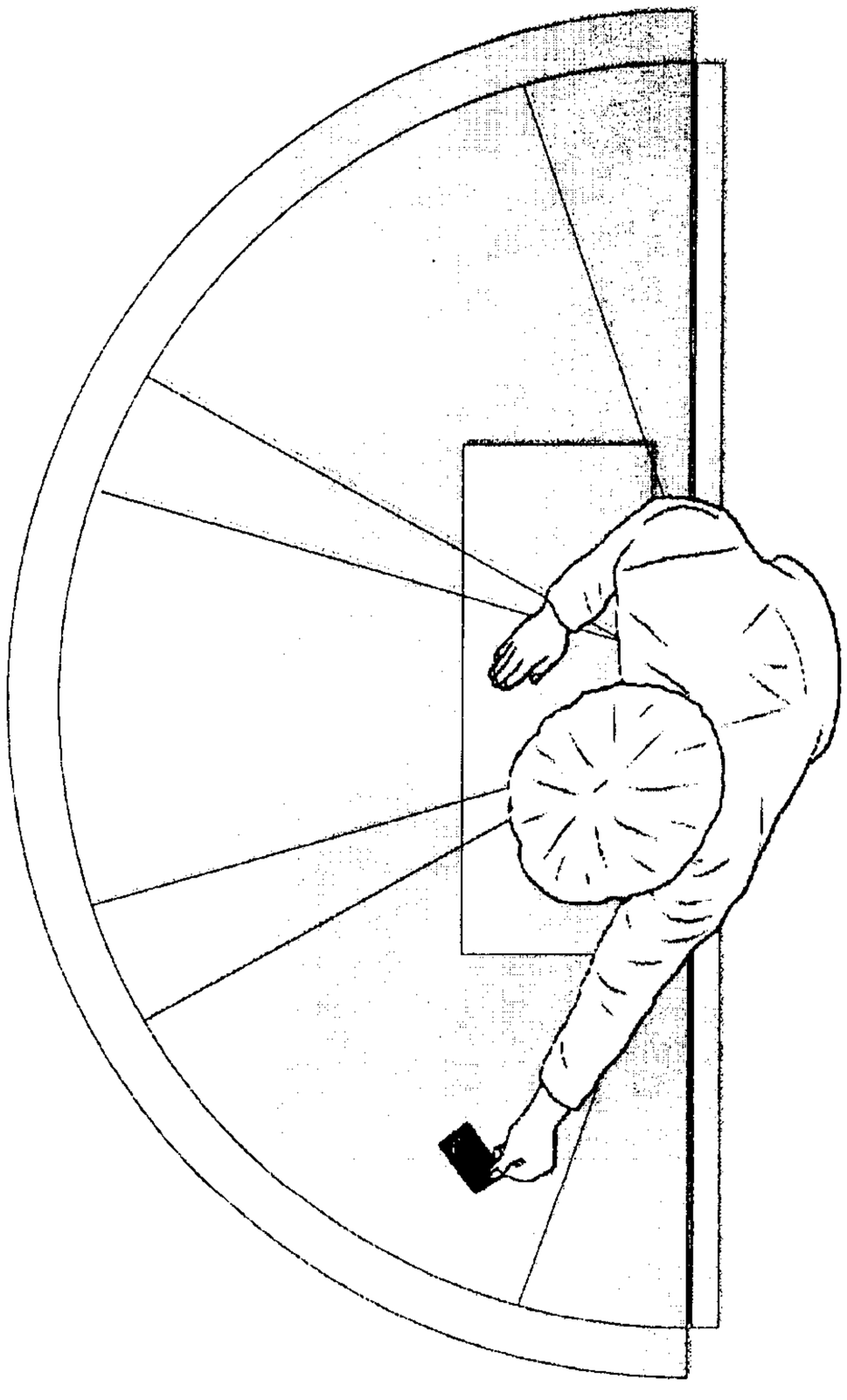


FIG. 25E

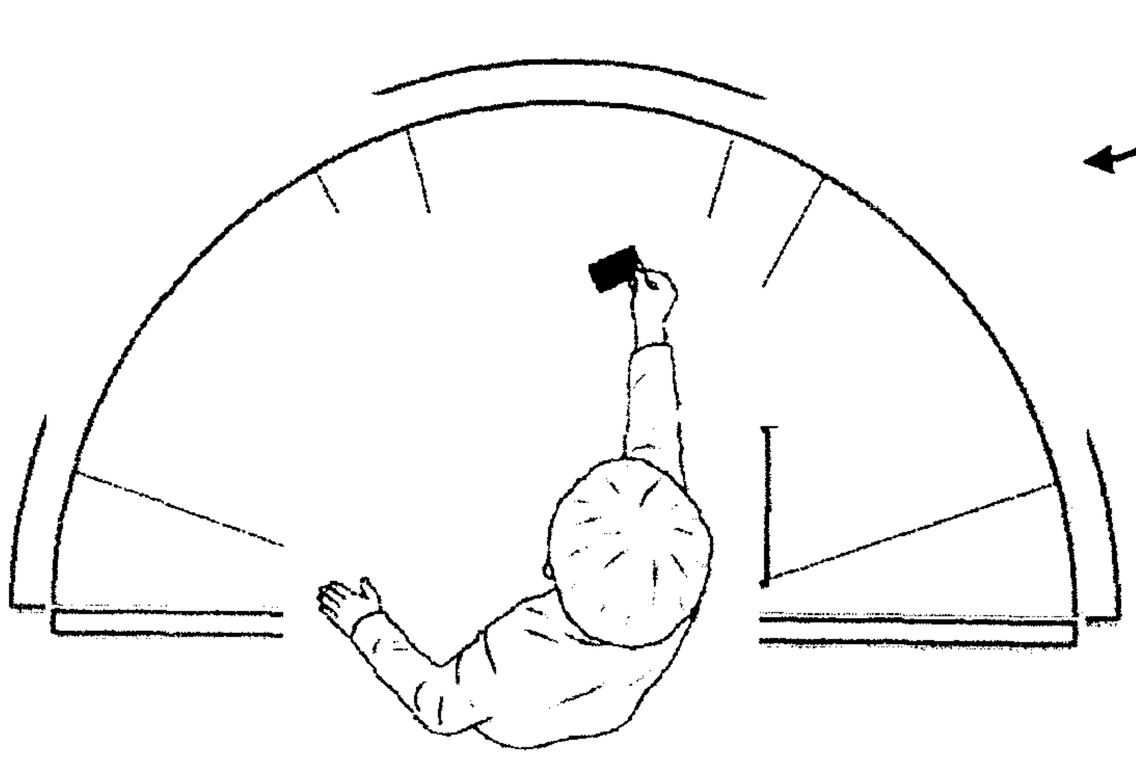


FIG. 26

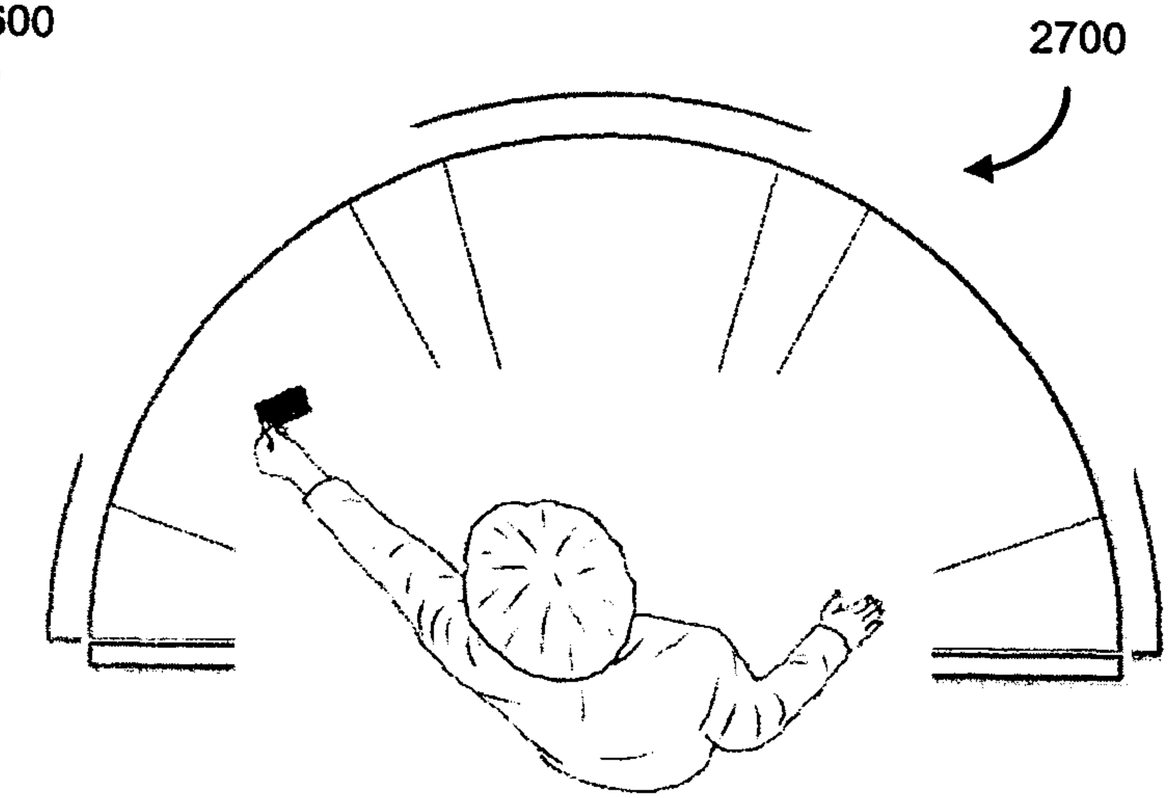


FIG. 27

CA 2970692 2017-06-15

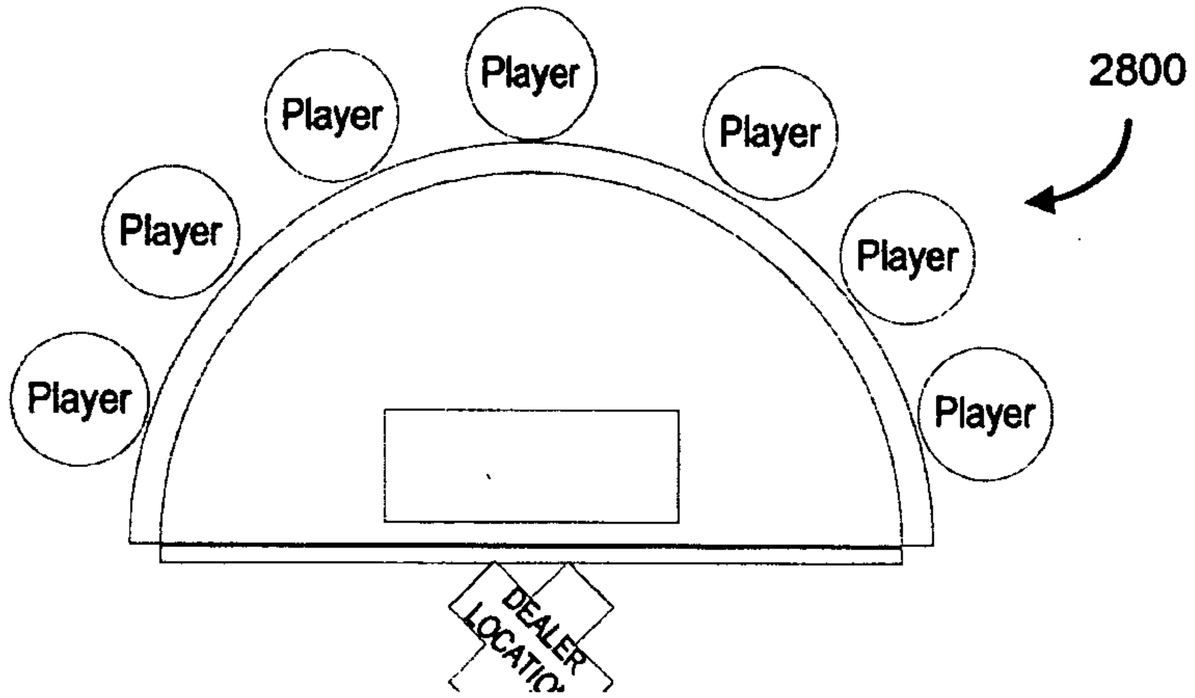


FIG. 28

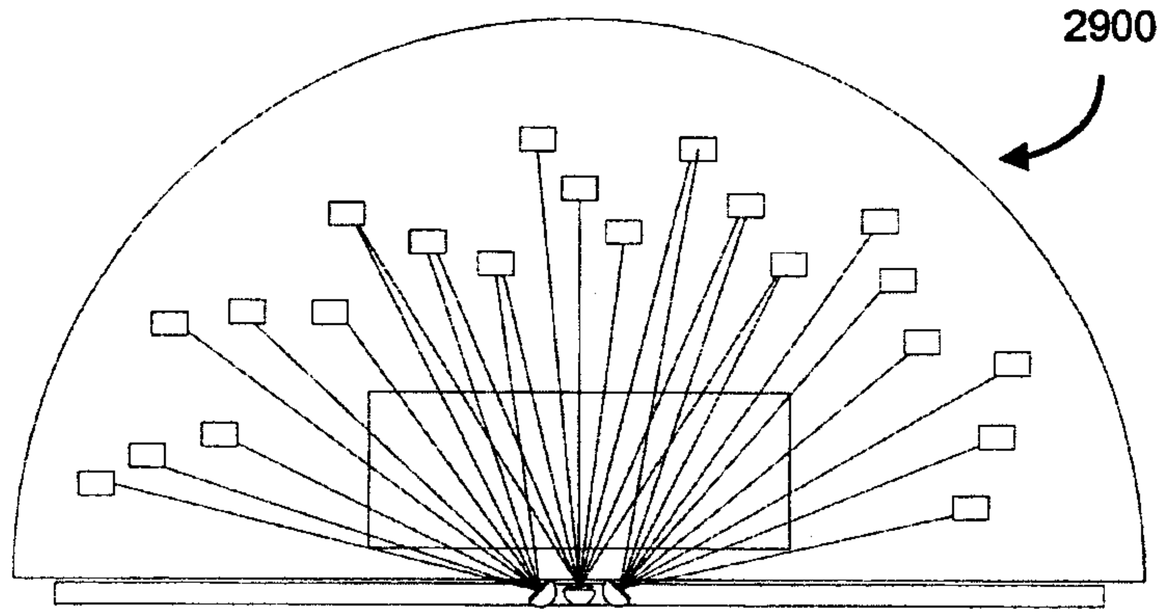


FIG. 29

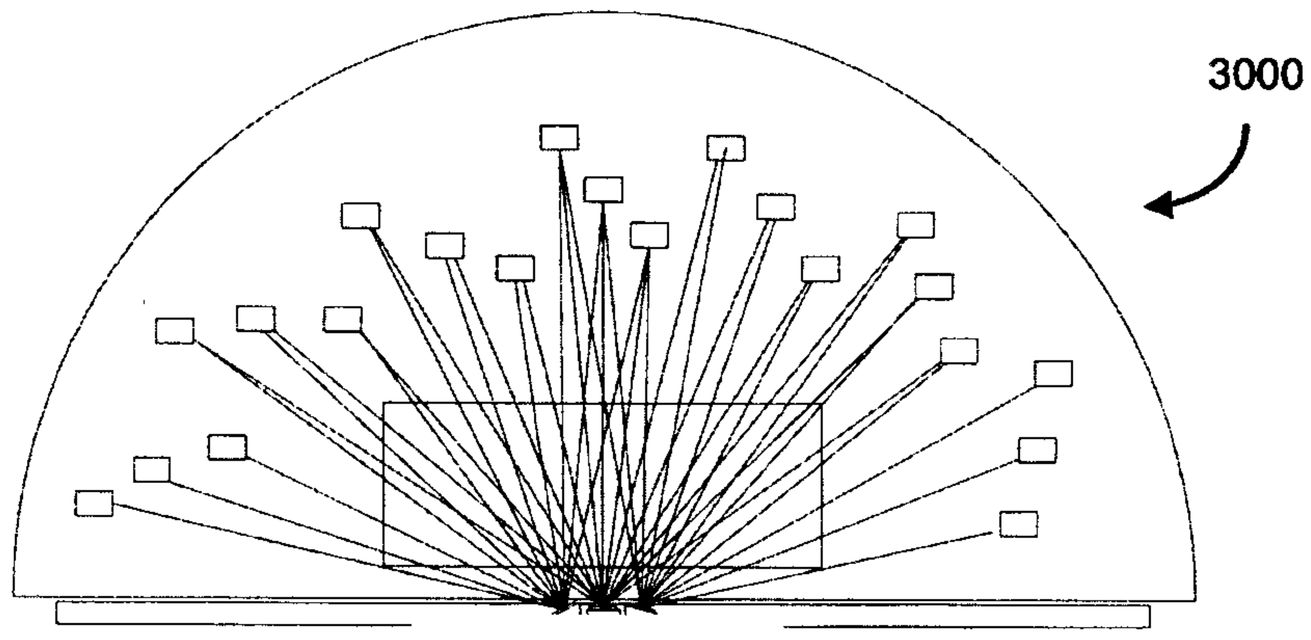


FIG. 30

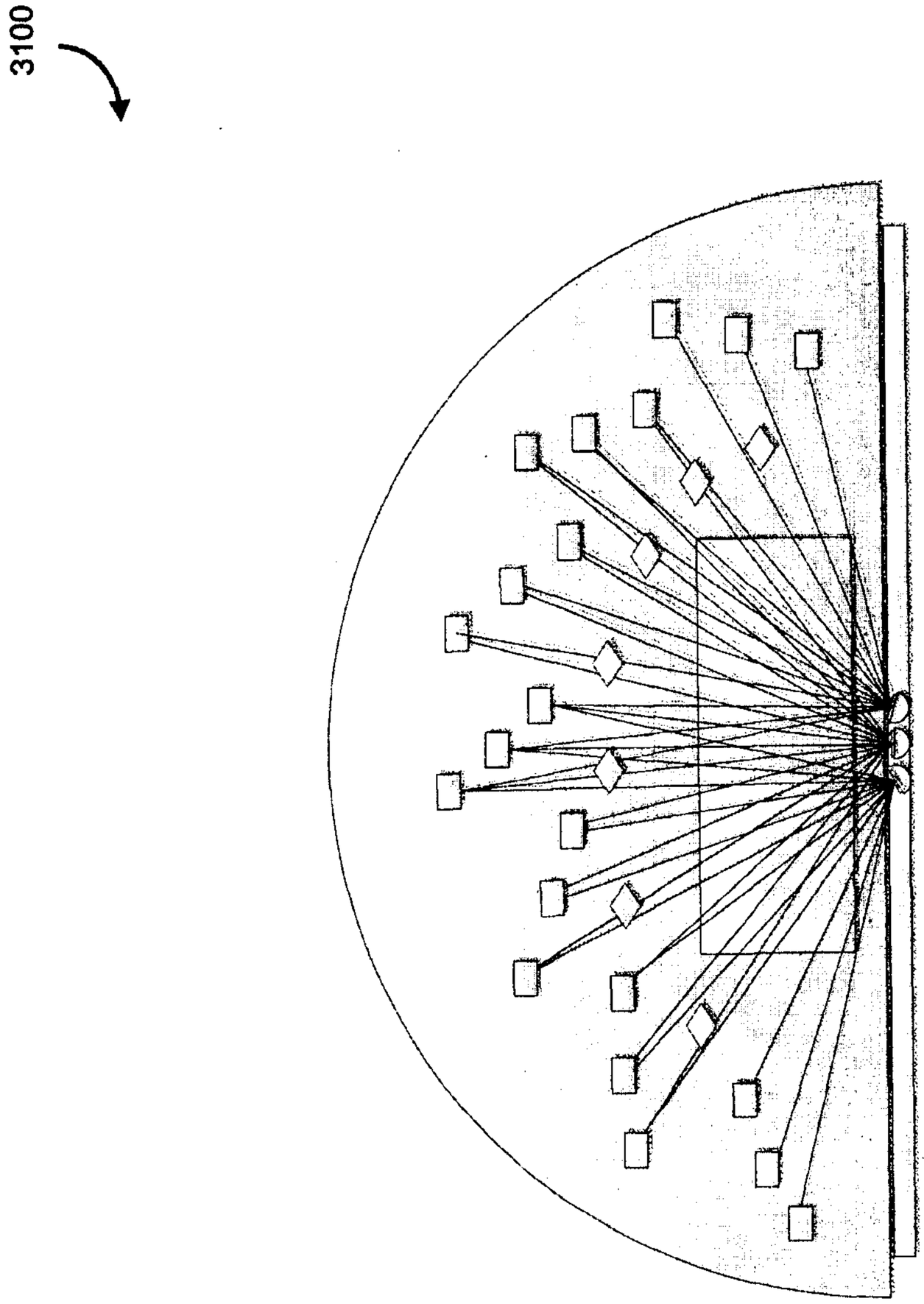


FIG. 31

3300

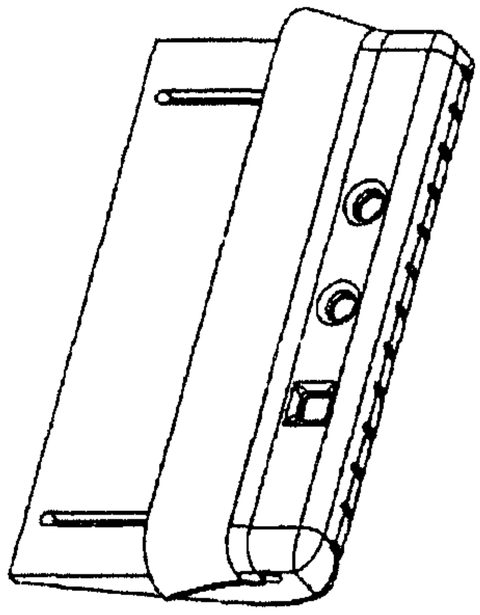


FIG. 33

3200

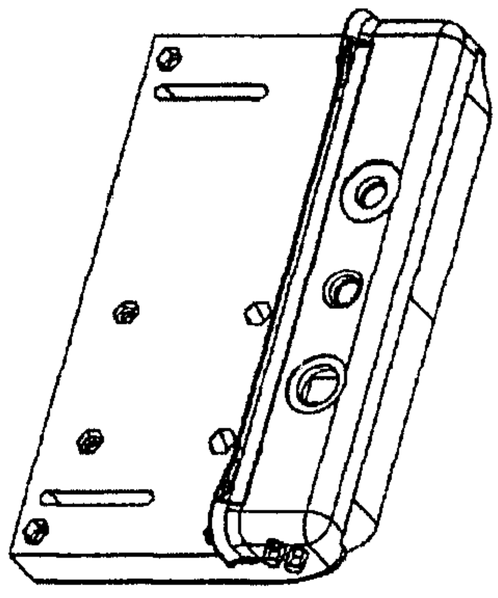


FIG. 32

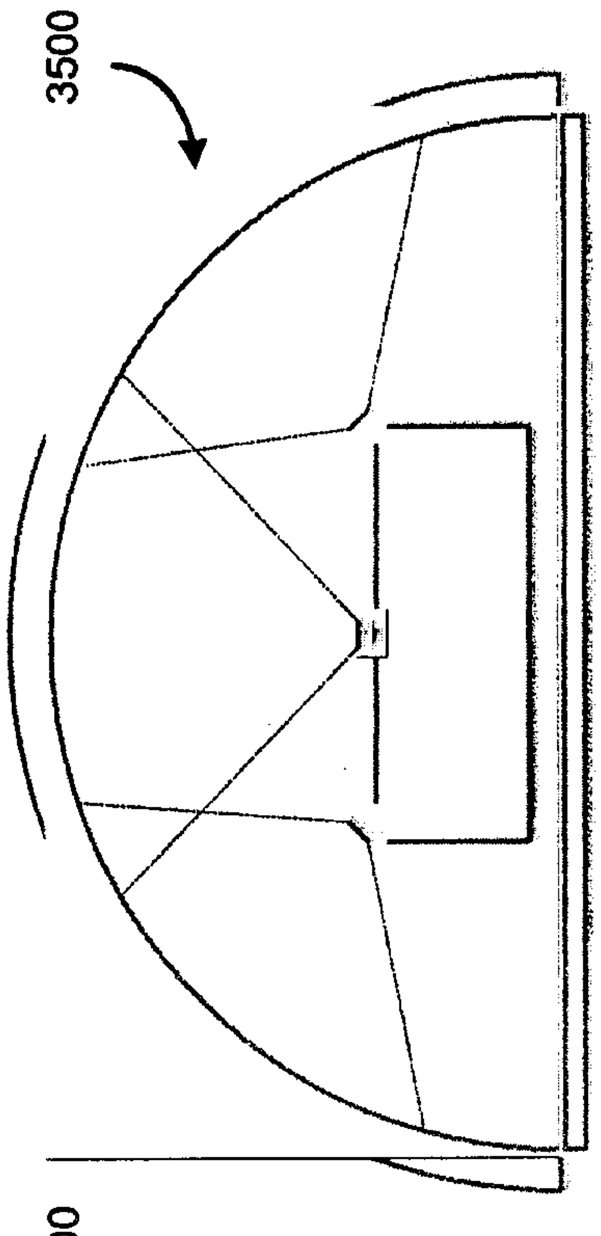


FIG. 35

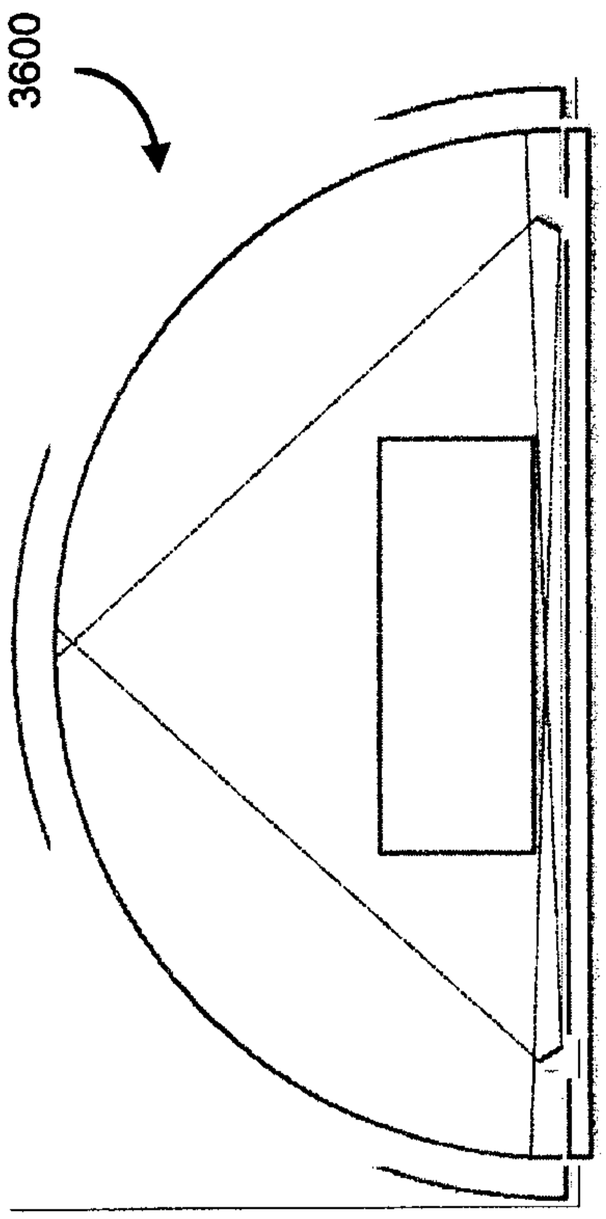


FIG. 36

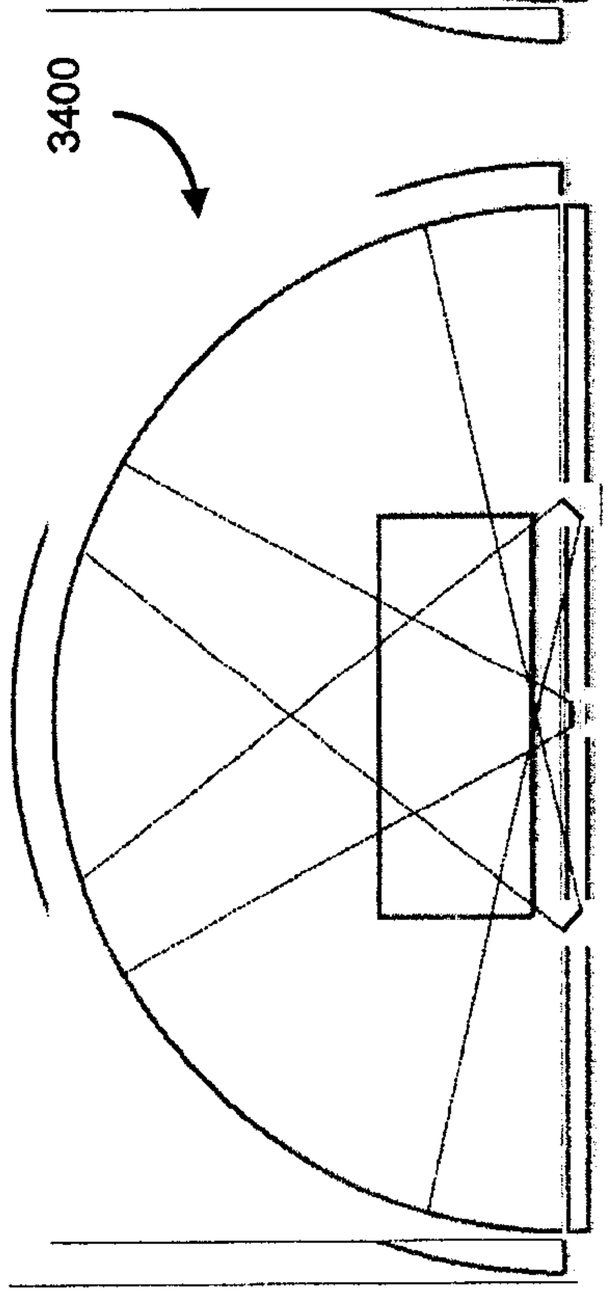


FIG. 34

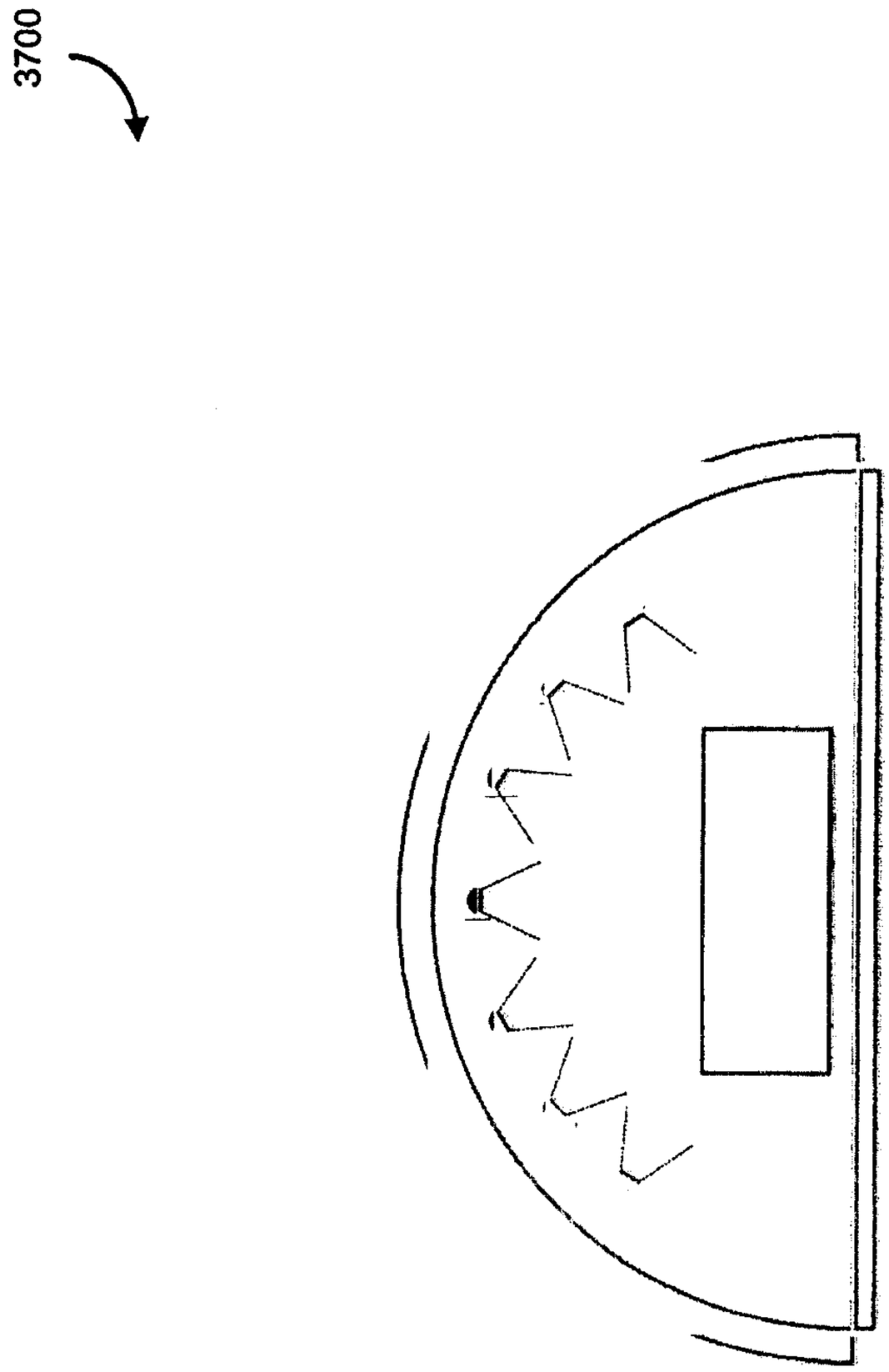


FIG. 37

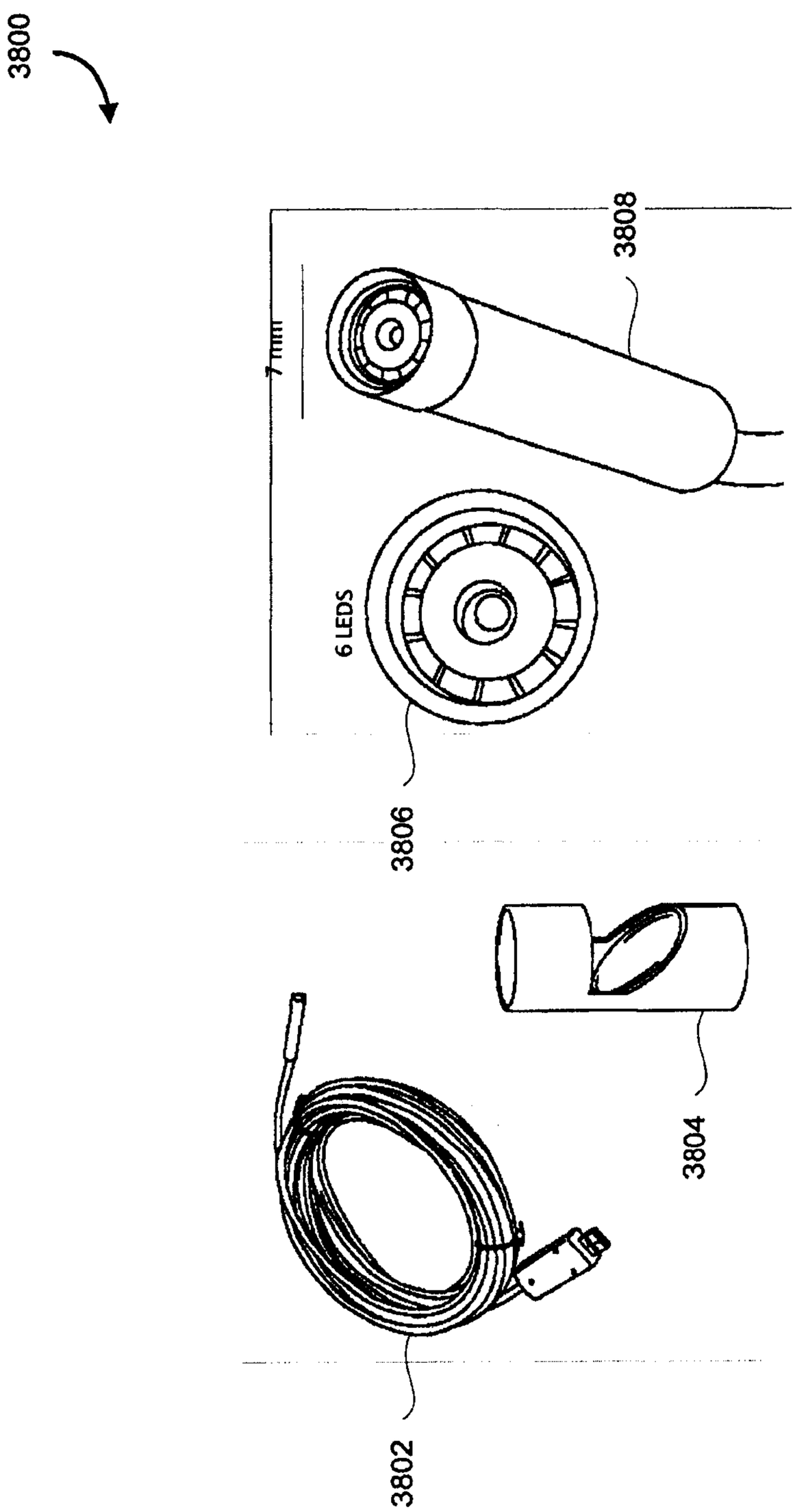


FIG. 38

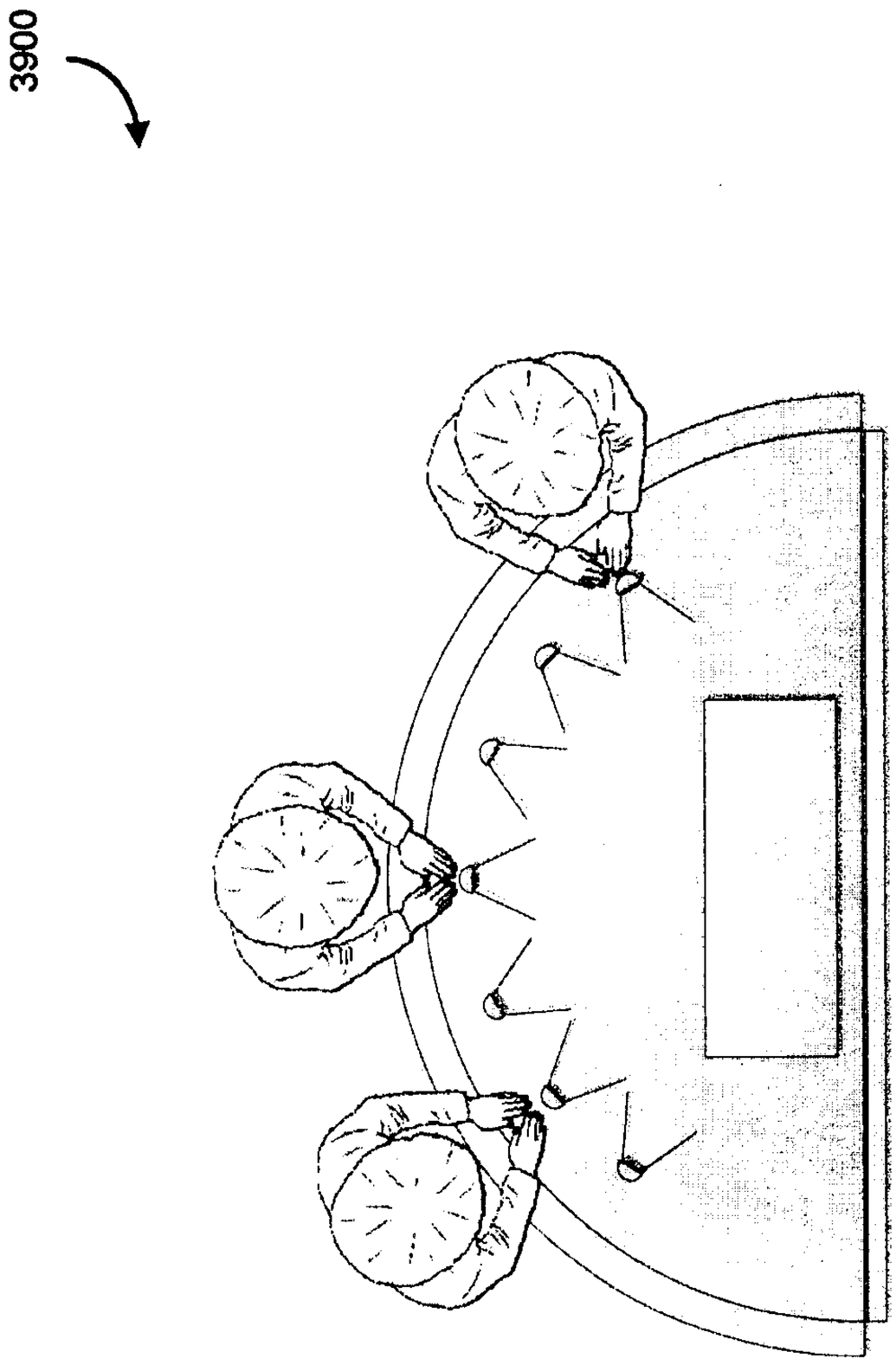


FIG. 39

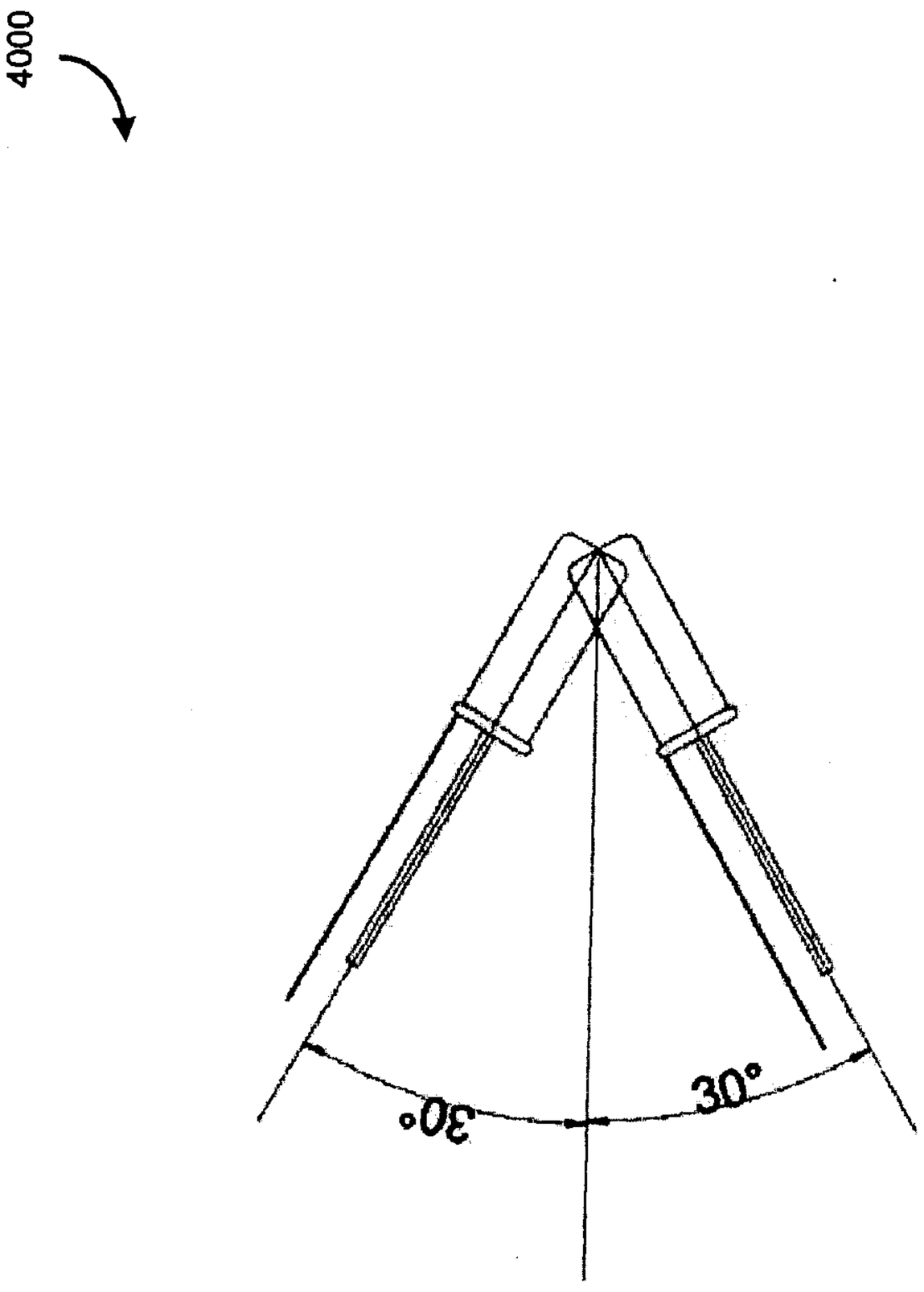


FIG. 40

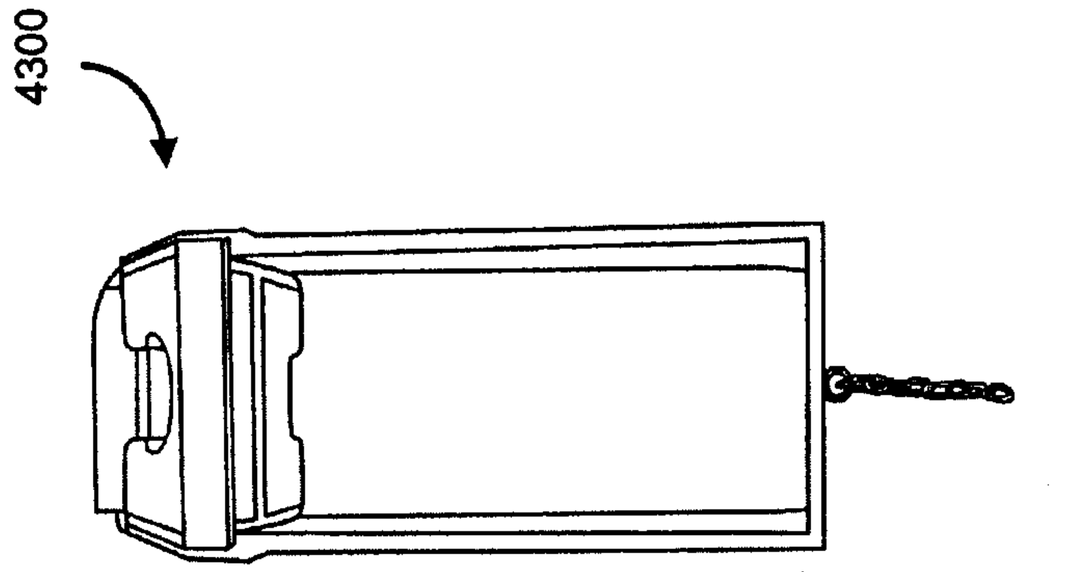


FIG. 43

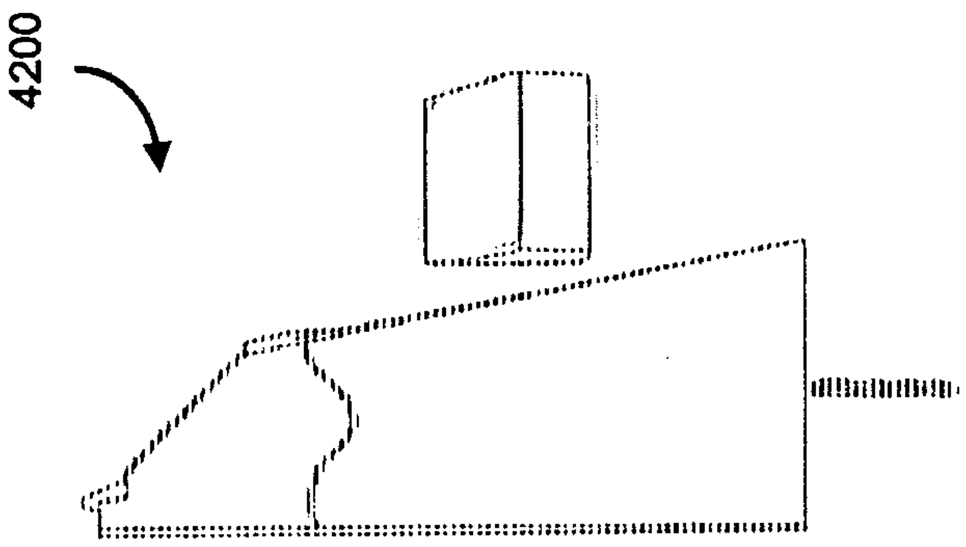


FIG. 42

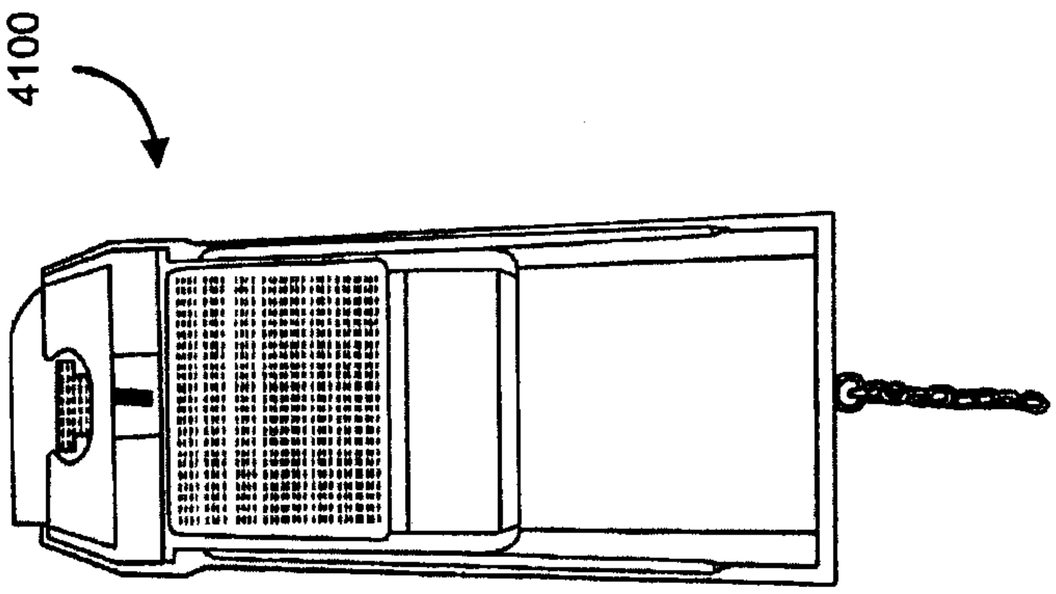


FIG. 41

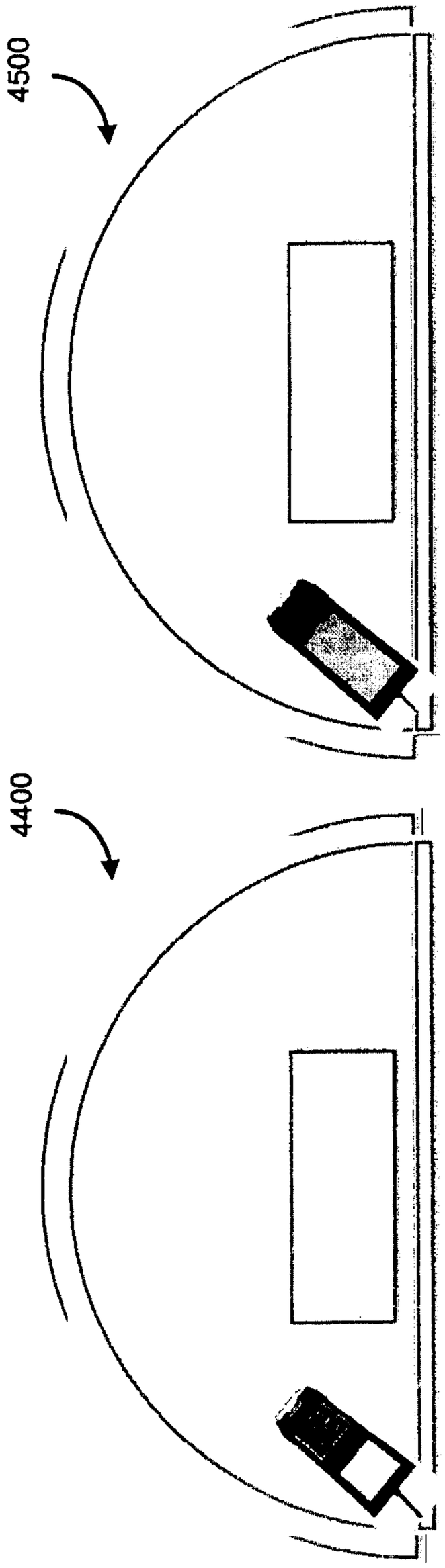


FIG. 45

FIG. 44

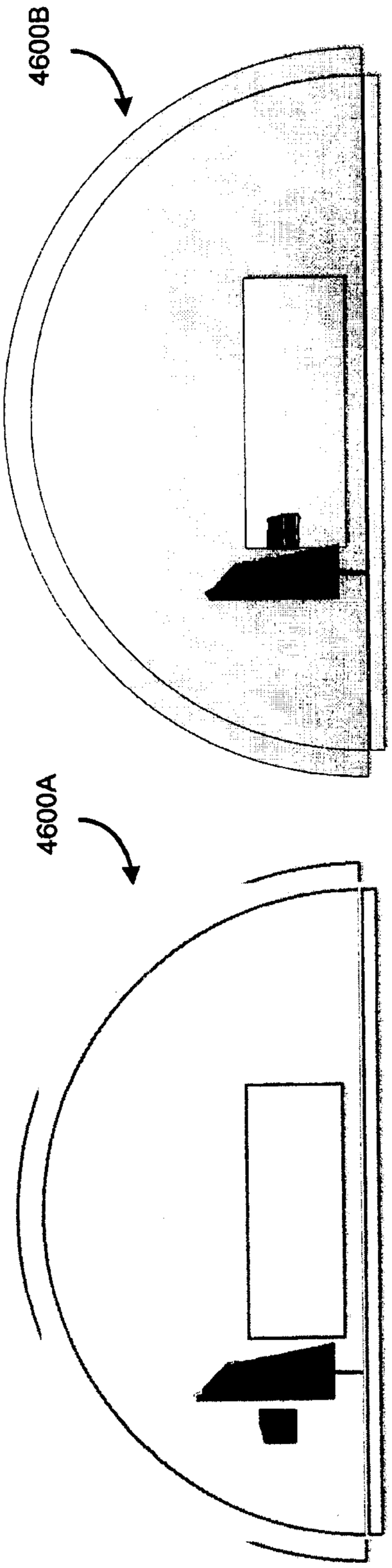


FIG. 46A

FIG. 46B

FIG. 46C

4800

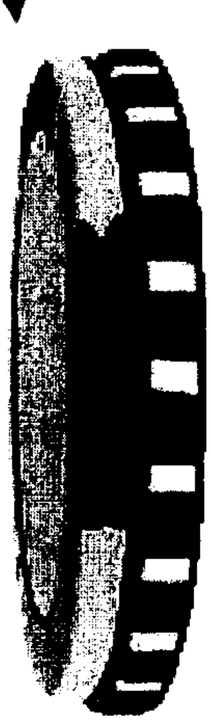


FIG. 48

4700



FIG. 47

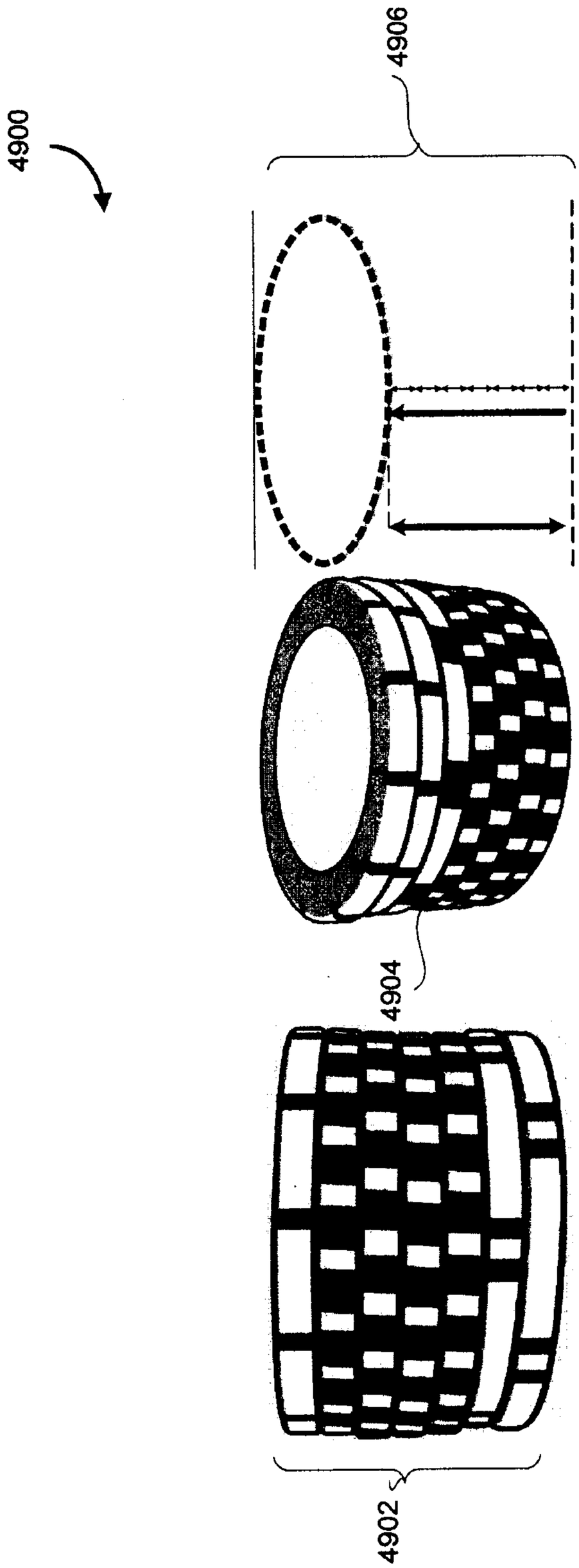


FIG. 49

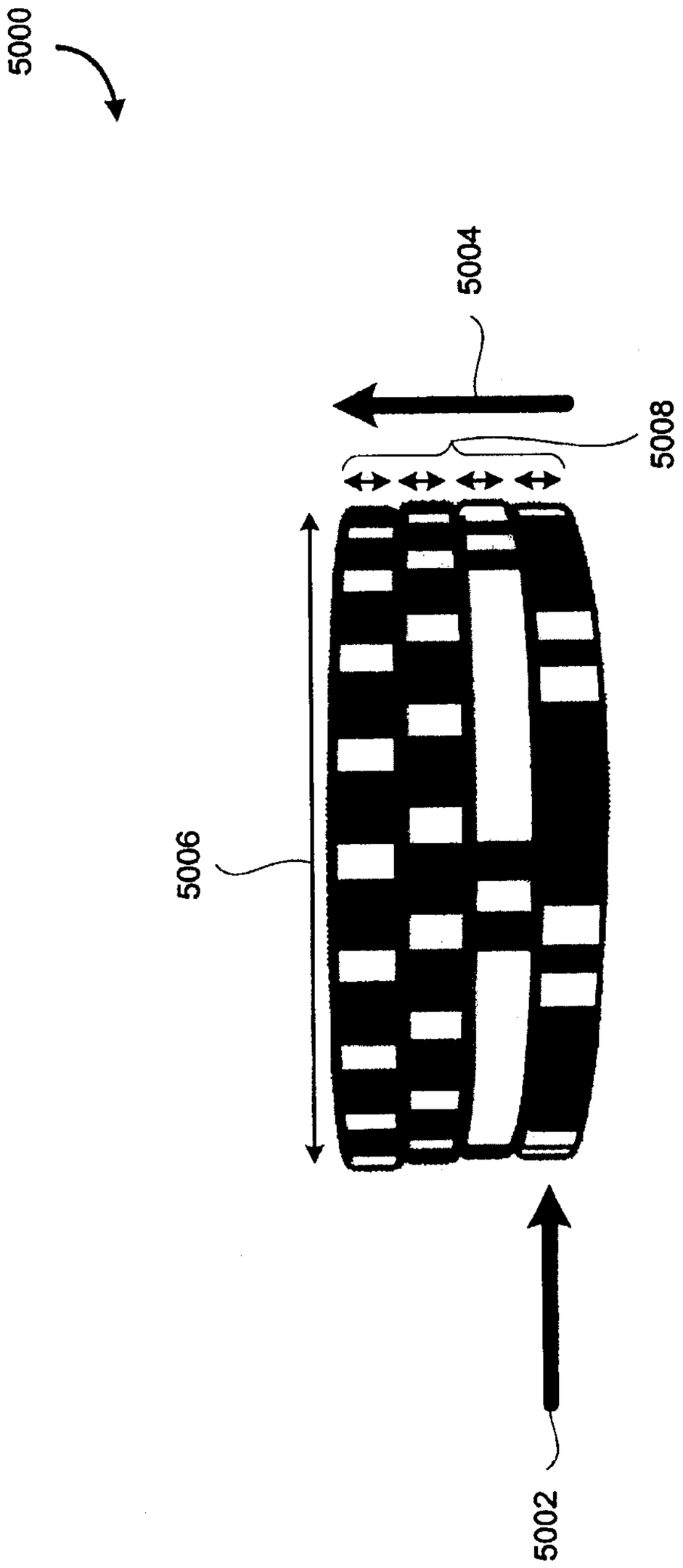


FIG. 50

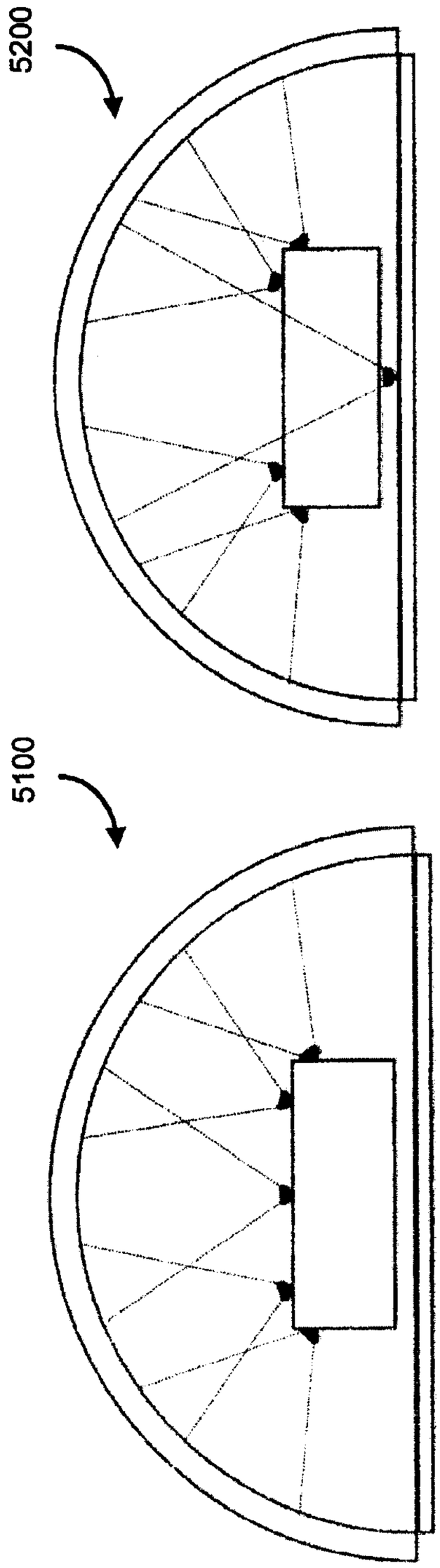


FIG. 52

FIG. 51

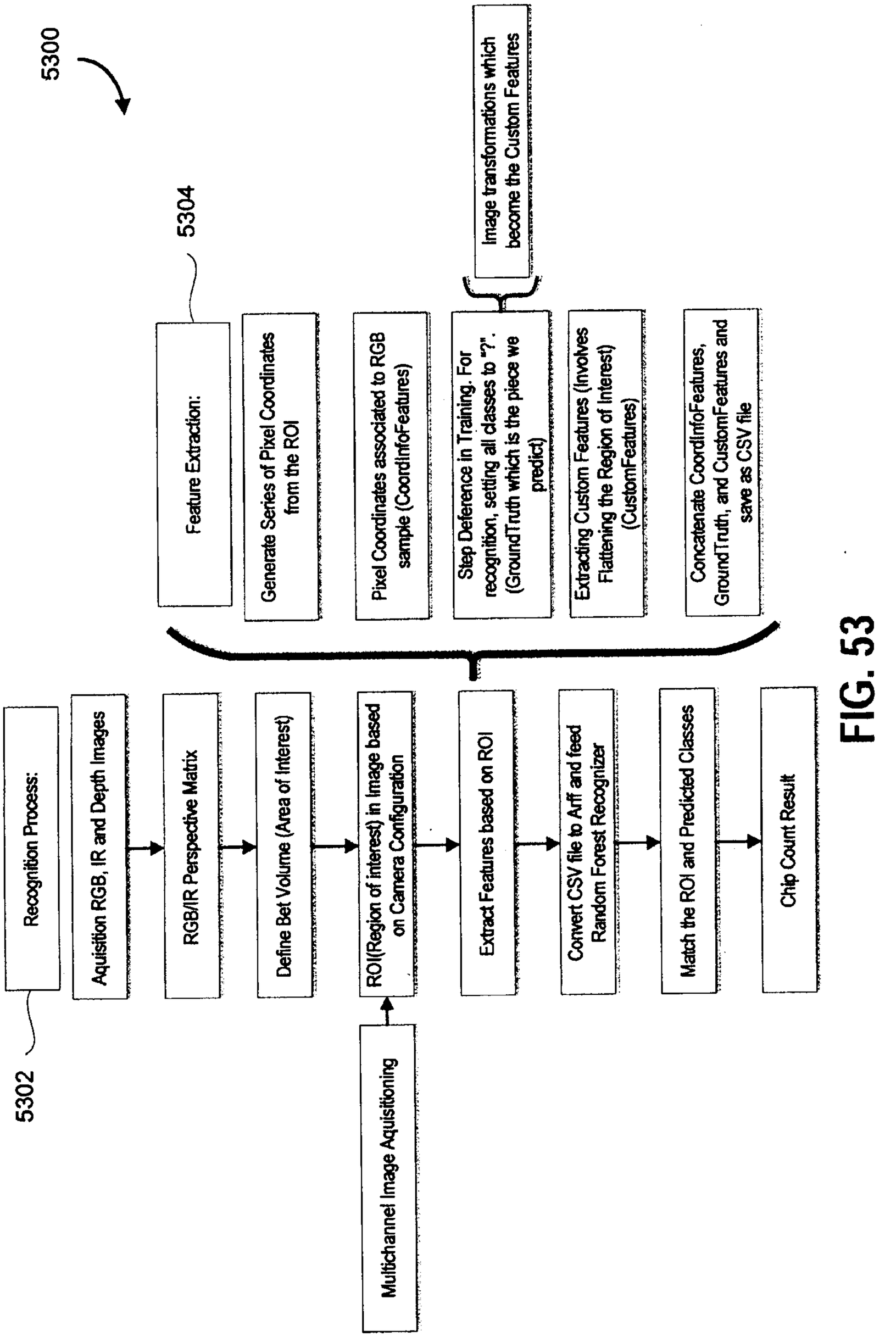

5300
5304
Feature Extraction:
Generate Series of Pixel Coordinates from the ROI
Pixel Coordinates associated to RGB sample (CoordinfoFeatures)
Step Deference in Training. For recognition, setting all classes to "?". (GroundTruth which is the piece we predict)
Image transformations which become the Custom Features
Extracting Custom Features (Involves Flattening the Region of Interest) (CustomFeatures)
Concatenate CoordinfoFeatures, GroundTruth, and CustomFeatures and save as CSV file
5302
Recognition Process:
Aquisition RGB, IR and Depth Images
RGB/IR Perspective Matrix
Define Bet Volume (Area of Interest)
ROI(Region of interest) in Image based on Camera Configuration
Extract Features based on ROI
Convert CSV file to Arff and feed Random Forest Recognizer
Match the ROI and Predicted Classes
Chip Count Result
Multichannel Image Aquisitioning

FIG. 53

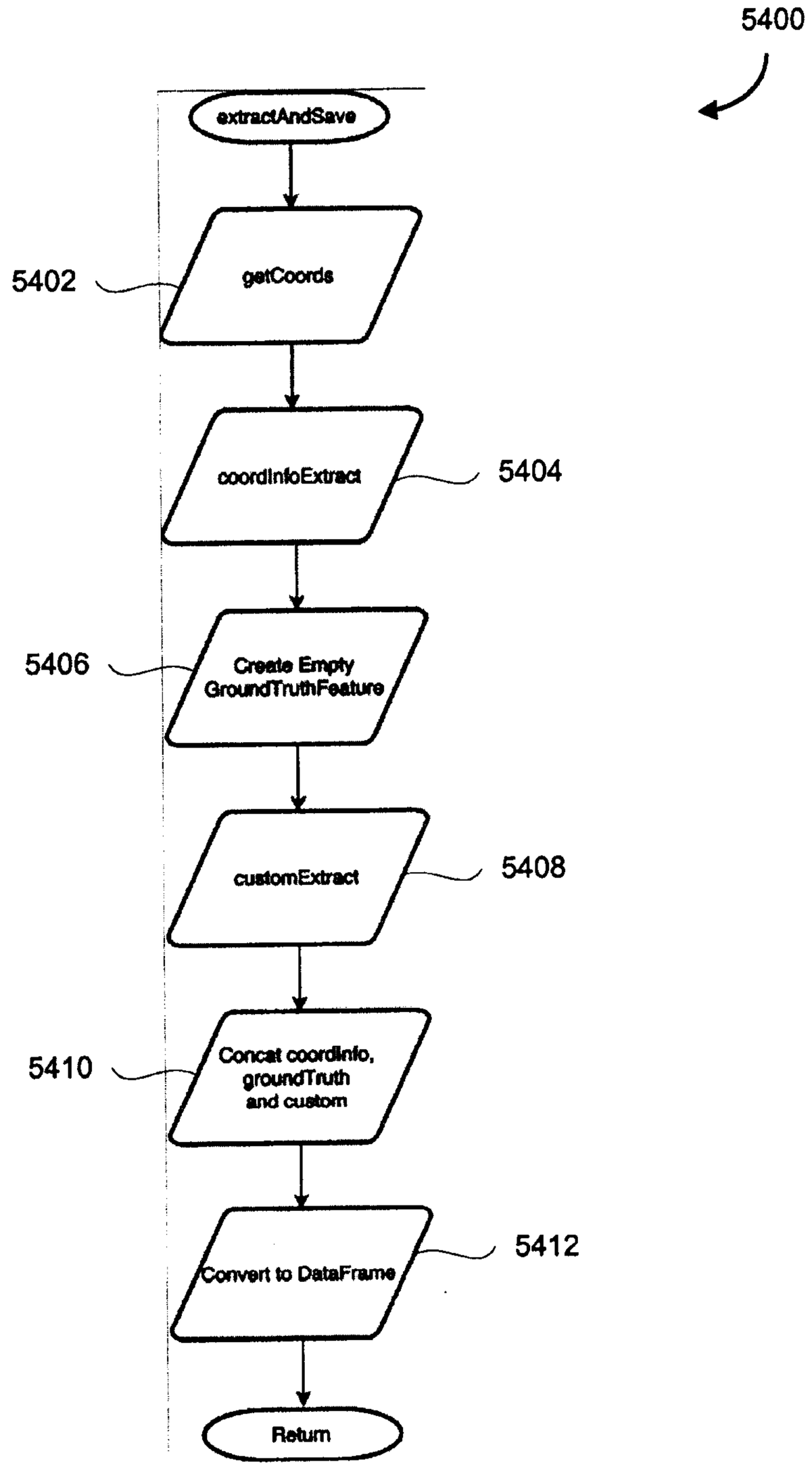

5400
extractAndSave
5402
getCoords
coordInfoExtract
5404
5406
Create Empty
GroundTruthFeature
customExtract
5408
5410
Concat coordInfo,
groundTruth
and custom
Convert to DataFrame
5412
Return

FIG. 54

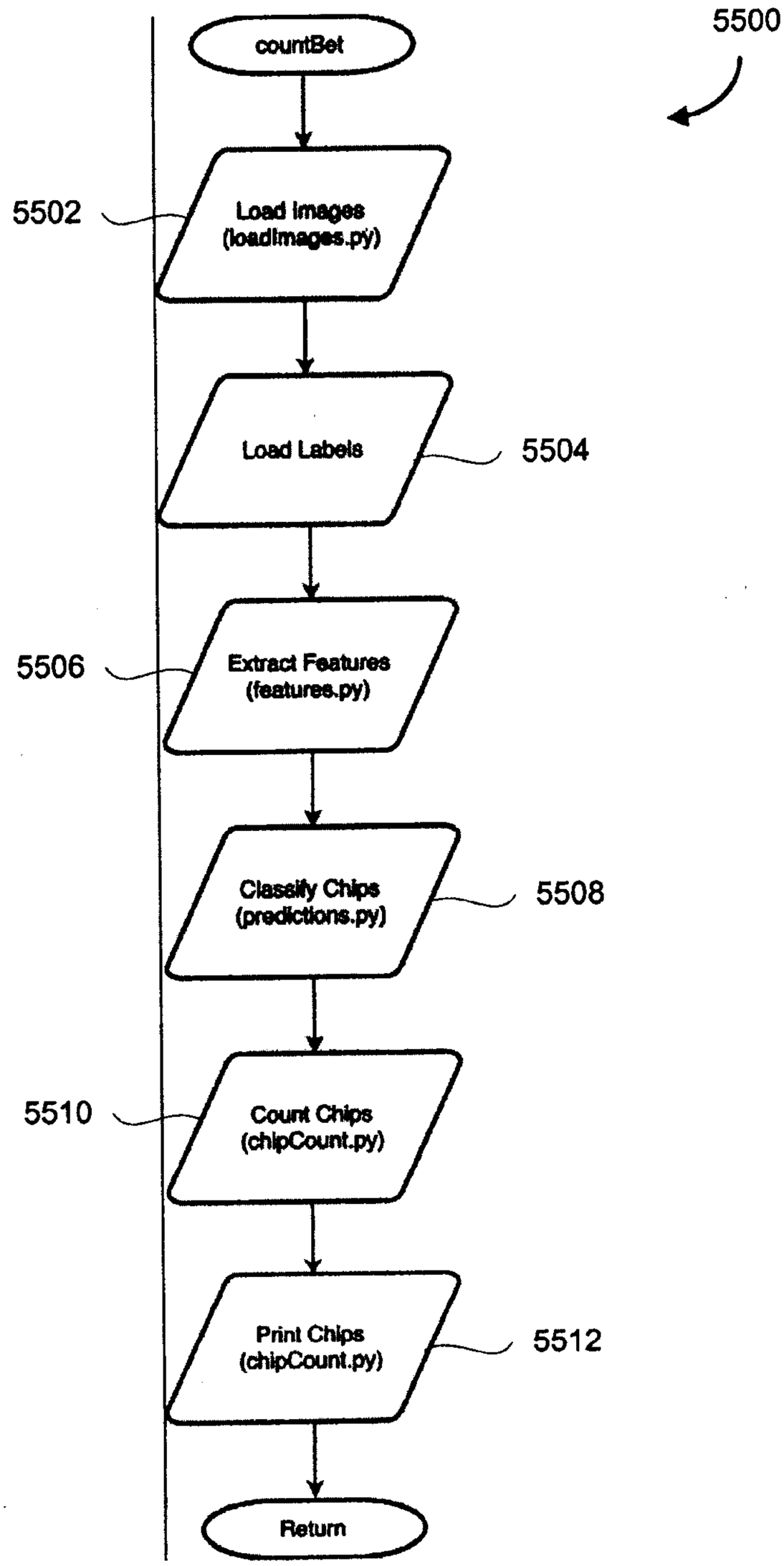

5500
countBet
5502
Load Images
(loadImages.py)
Load Labels
5504
5506
Extract Features
(features.py)
Classify Chips
(predictions.py)
5508
5510
Count Chips
(chipCount.py)
Print Chips
(chipCount.py)
5512
Return

FIG. 55

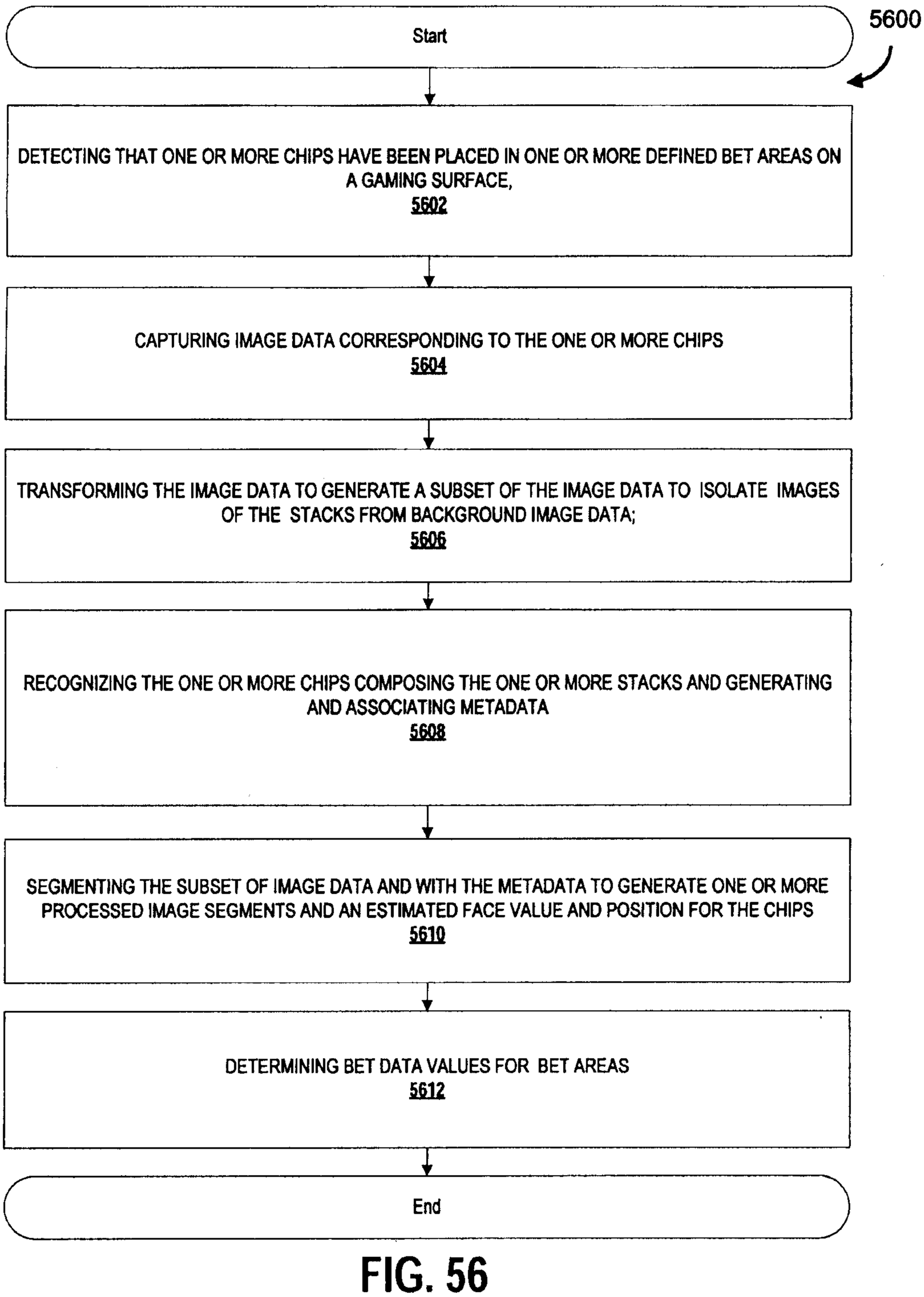
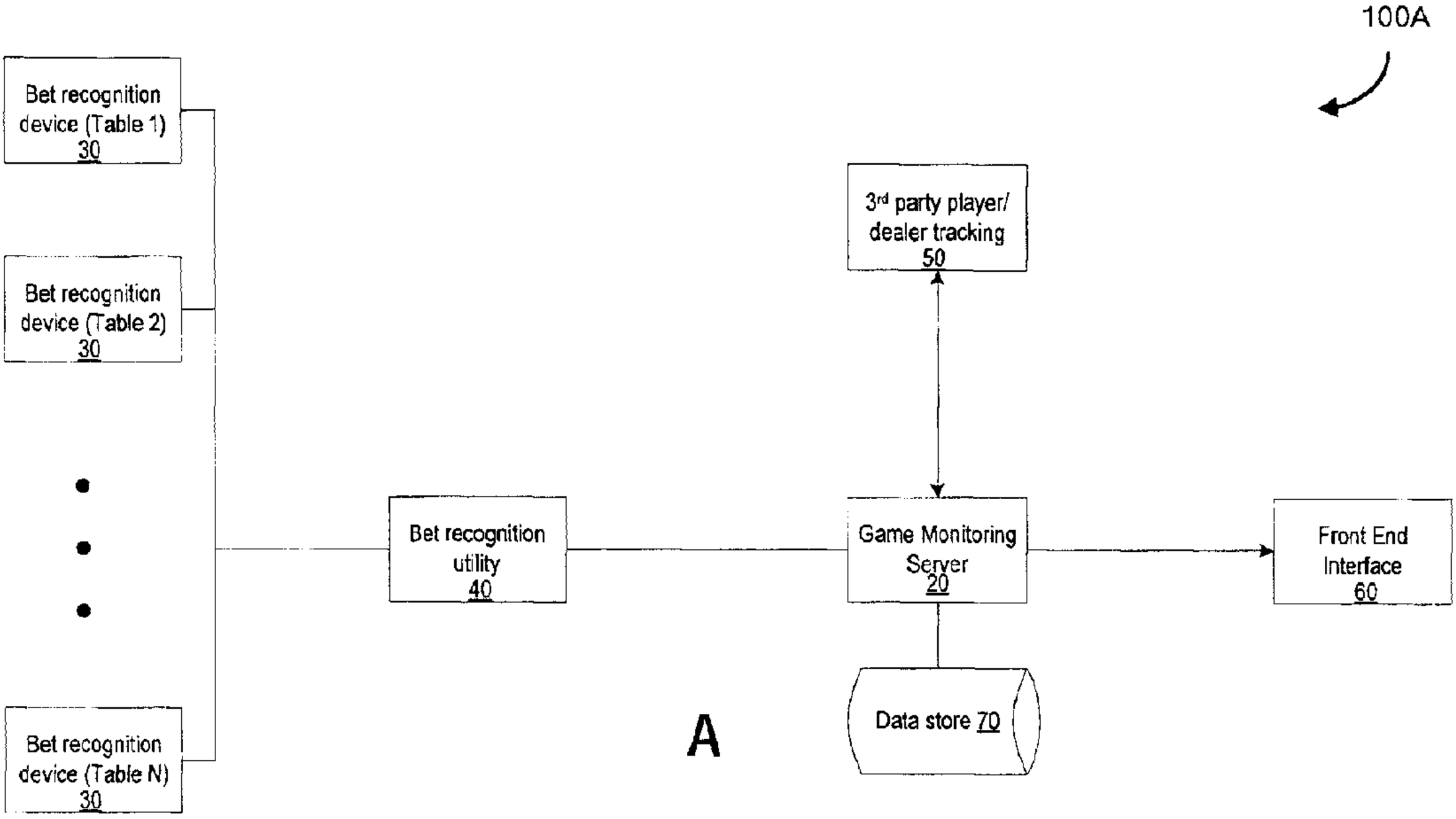

Start
5600
DETECTING THAT ONE OR MORE CHIPS HAVE BEEN PLACED IN ONE OR MORE DEFINED BET AREAS ON A GAMING SURFACE,
5602
CAPTURING IMAGE DATA CORRESPONDING TO THE ONE OR MORE CHIPS
5604
TRANSFORMING THE IMAGE DATA TO GENERATE A SUBSET OF THE IMAGE DATA TO ISOLATE IMAGES OF THE STACKS FROM BACKGROUND IMAGE DATA;
5606
RECOGNIZING THE ONE OR MORE CHIPS COMPOSING THE ONE OR MORE STACKS AND GENERATING AND ASSOCIATING METADATA
5608
SEGMENTING THE SUBSET OF IMAGE DATA AND WITH THE METADATA TO GENERATE ONE OR MORE PROCESSED IMAGE SEGMENTS AND AN ESTIMATED FACE VALUE AND POSITION FOR THE CHIPS
5610
DETERMINING BET DATA VALUES FOR BET AREAS
5612
End

FIG. 56


100A
Bet recognition device (Table 1) 30
Bet recognition device (Table 2) 30
Bet recognition device (Table N) 30
Bet recognition utility 40
3rd party player/ dealer tracking 50
Game Monitoring Server 20
Front End Interface 60
Data store 70
A