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(54) **V2V AND V2X COMMUNICATIONS IN 5G AND 6G BASED ON DISPLAYED MATRIX**

(71) Applicants: **David E. Newman**, Poway, CA (US);
R. Kemp Massengill, Palos Verdes, CA (US)

(72) Inventors: **David E. Newman**, Poway, CA (US);
R. Kemp Massengill, Palos Verdes, CA (US)

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H04W 4/90 (2006.01)

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(57) **ABSTRACT**

Disclosed is a “connectivity matrix” that wireless entities (vehicles, fixed assets, etc.) can display indicating the 5G/6G wireless address of the entity. Other wireless devices can then image the connectivity matrix, determine the wireless address, and then communicate in sidelink, on frequencies allocated for ad-hoc networking. Alternatively, the two entities can communicate through a local base station, on managed channels, using the displayed wireless address. The matrix can provide additional information, such as the frequency, bandwidth, and modulation scheme favored by the entity. Alternatively, the matrix can provide a key code maintained by a central authority, so that a second wireless entity can read the code and request the associated wireless address (and frequency, bandwidth, etc.) from the central authority. By either method, the two wireless entities can then communicate explicitly thereafter.

100

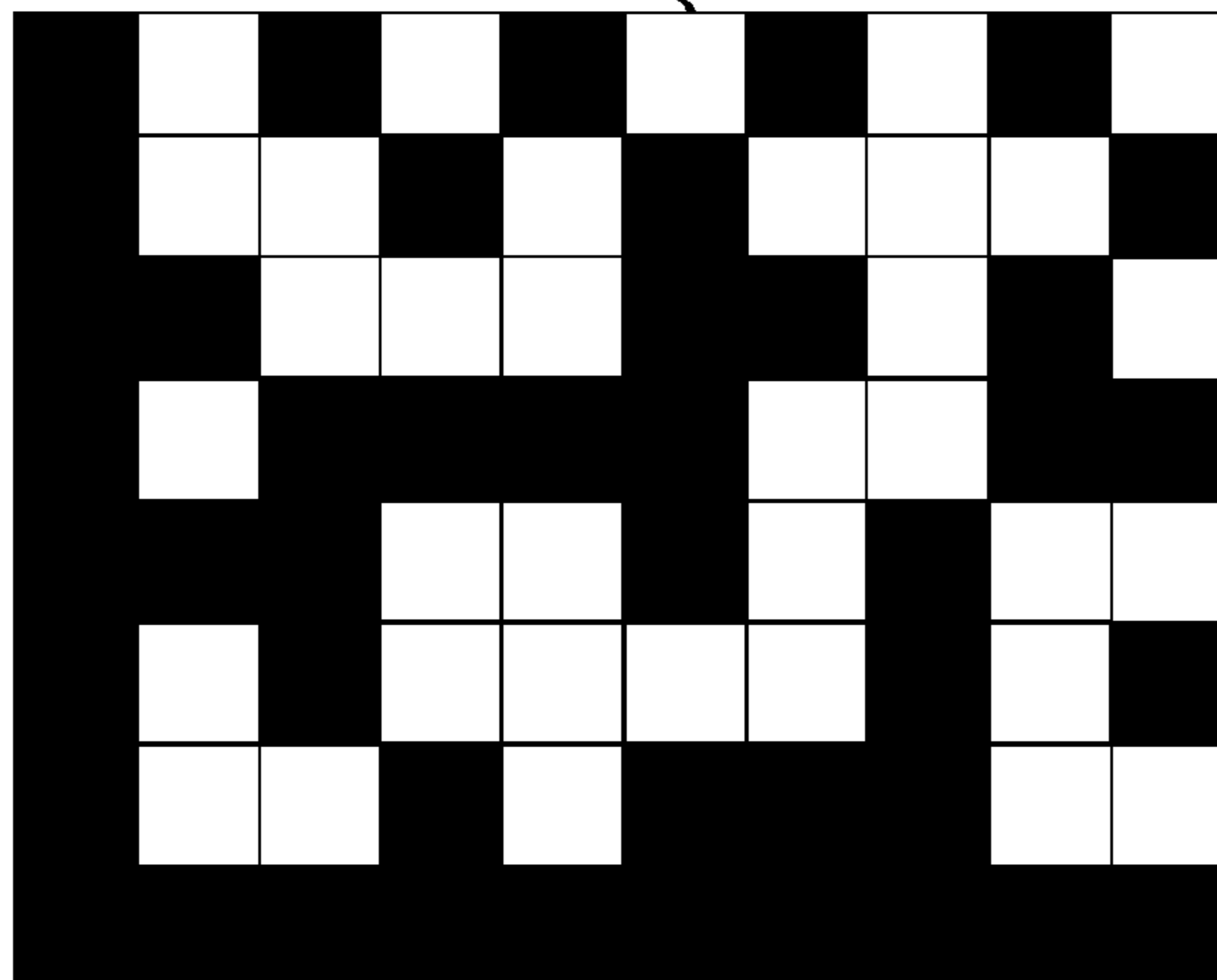


FIG. 1A

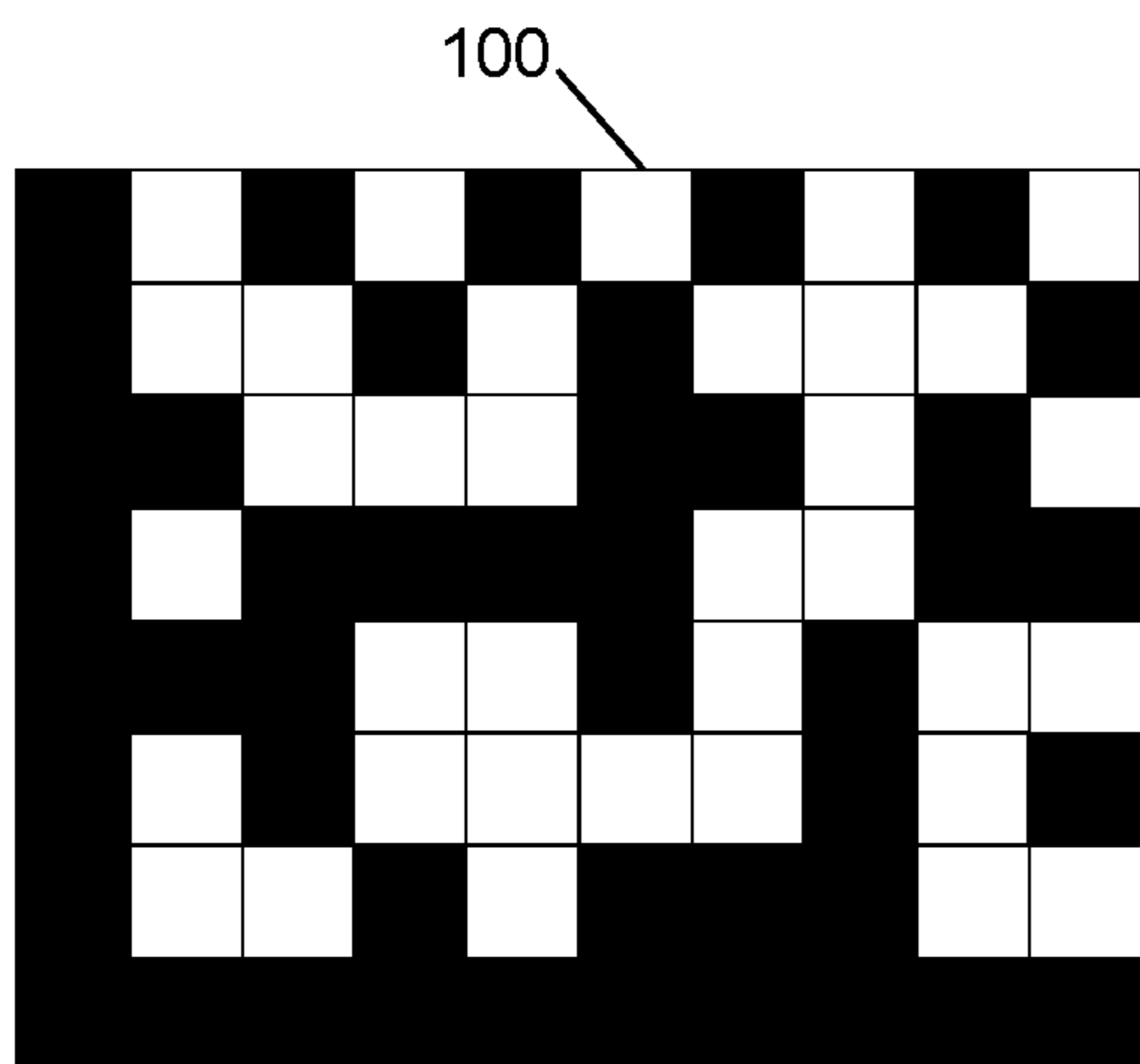


FIG. 1B

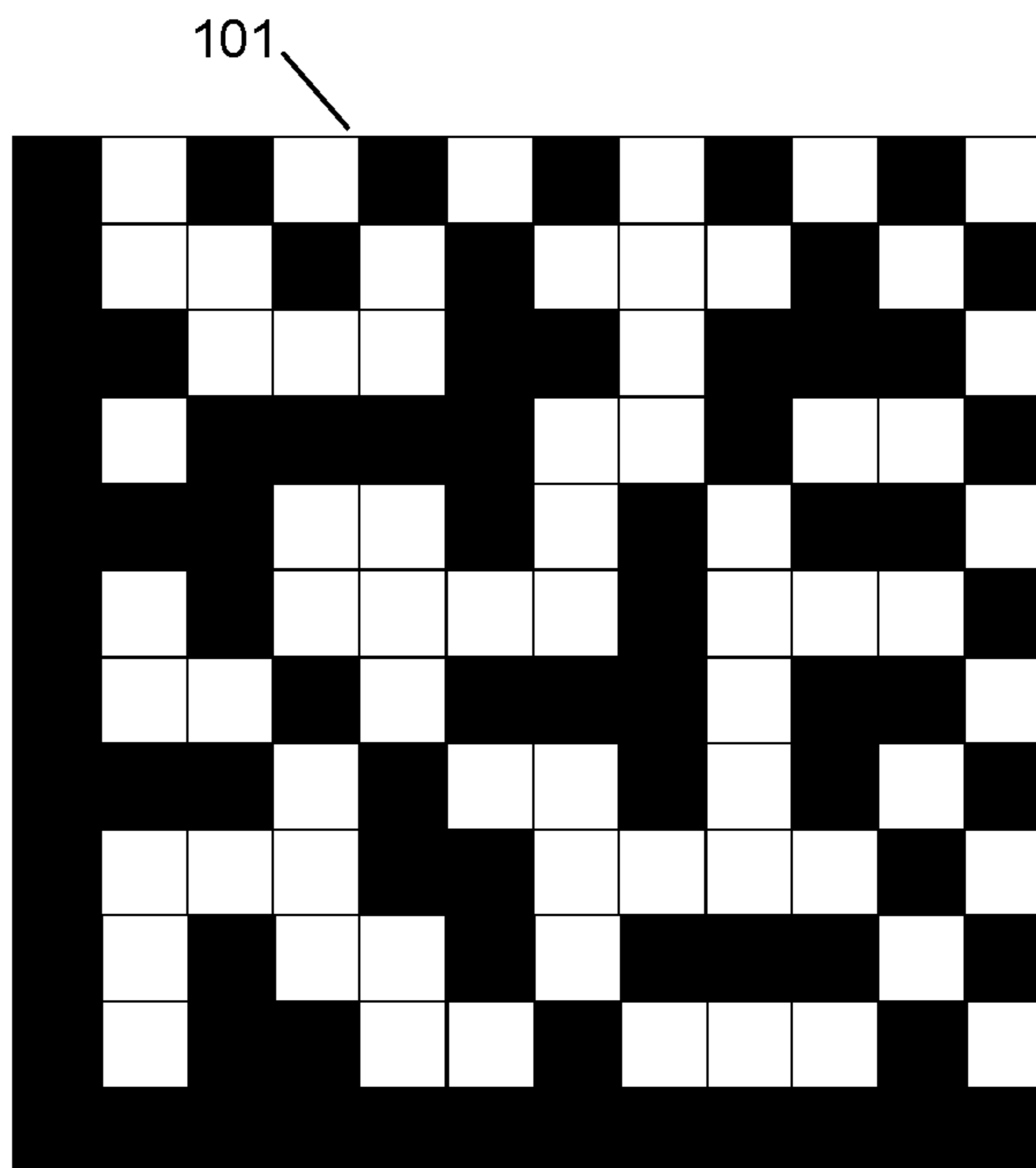


FIG. 1C

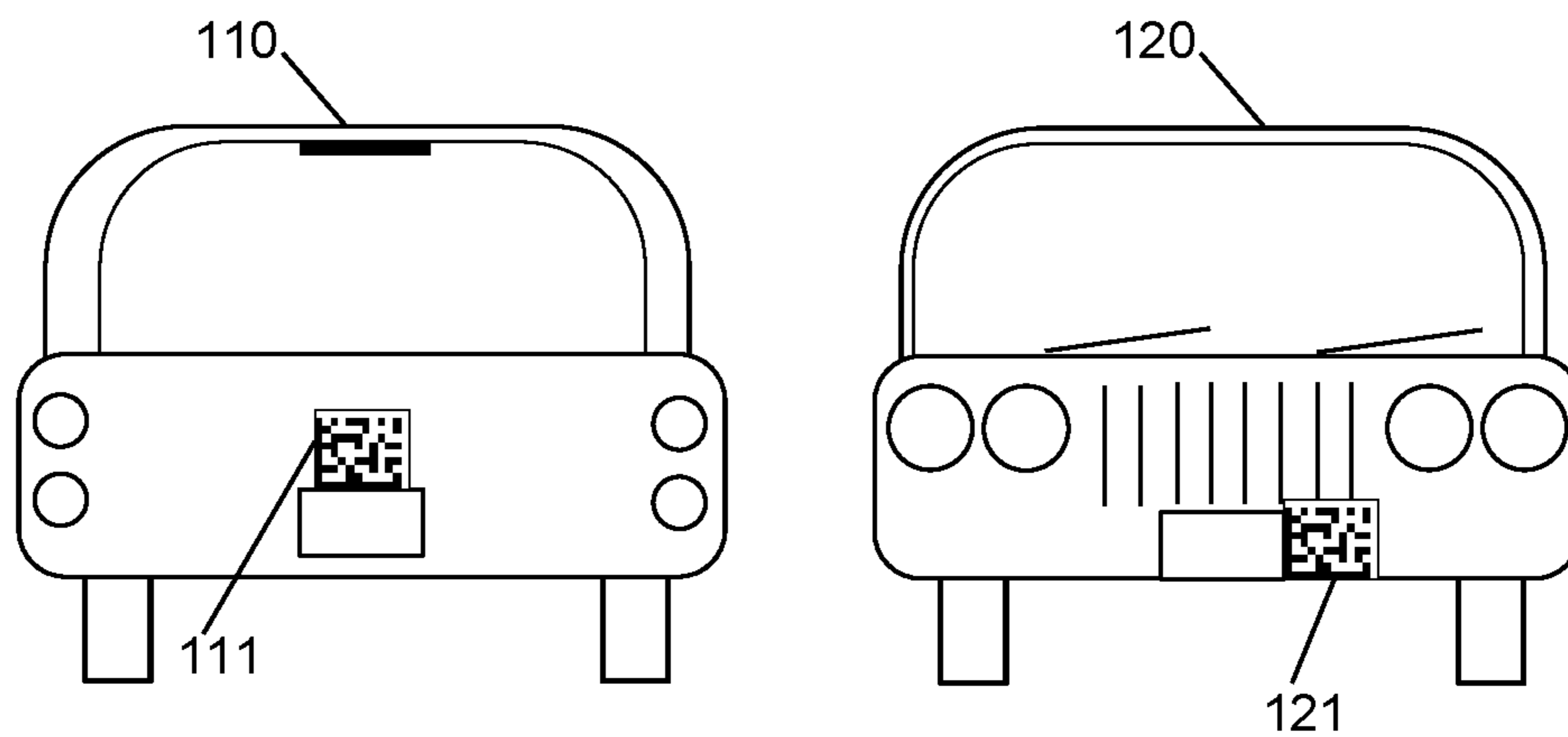


FIG. 2A

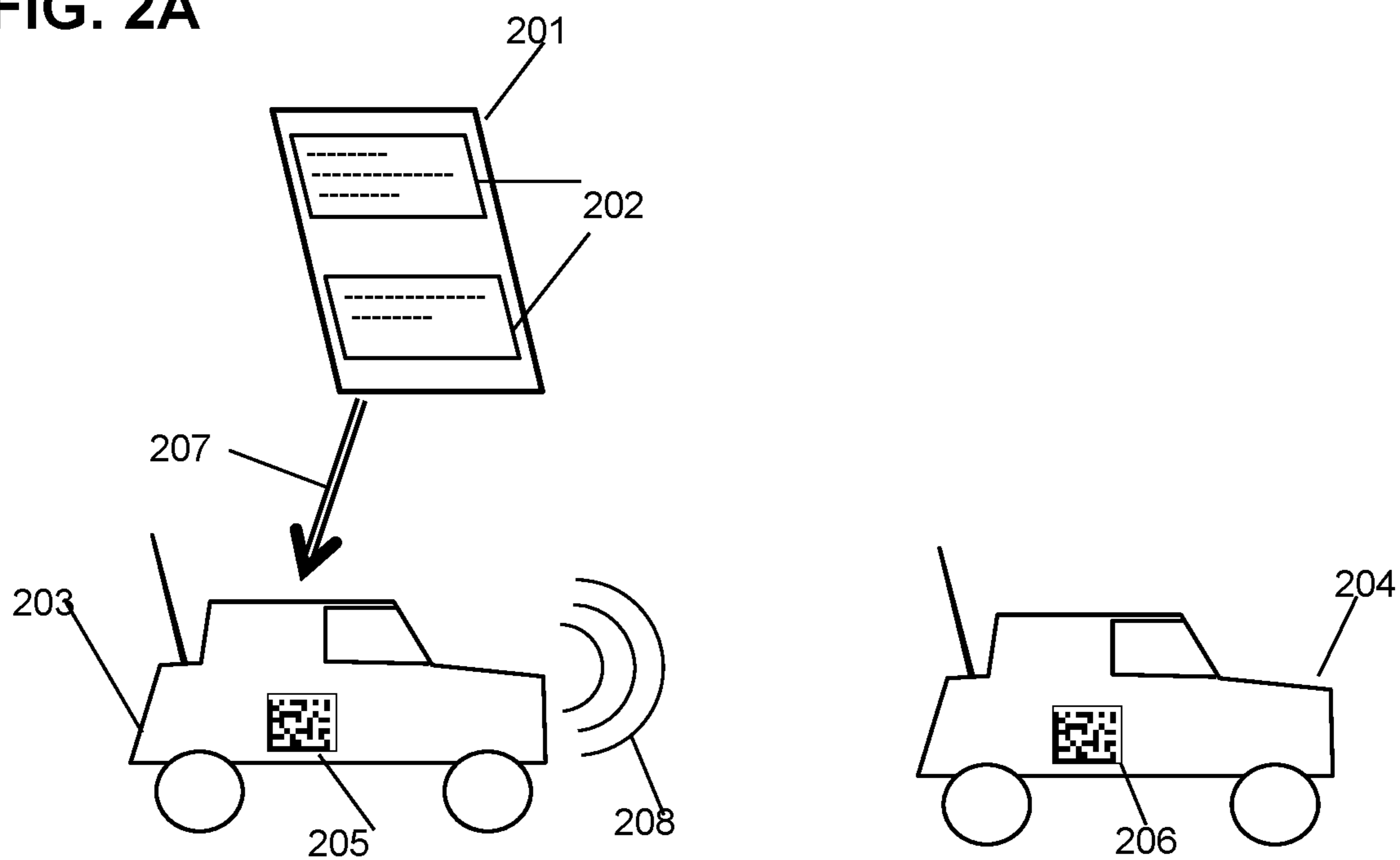


FIG. 2B

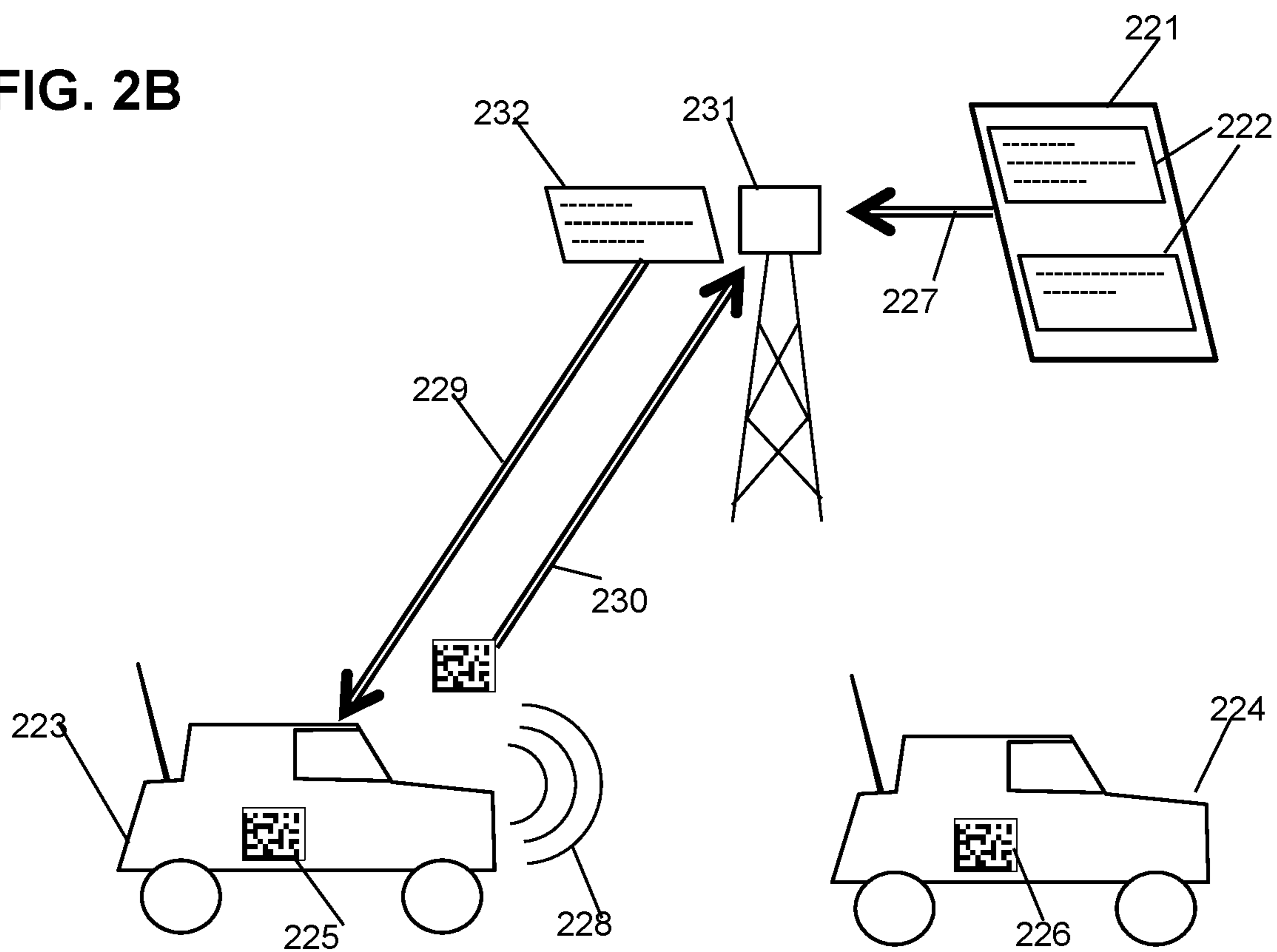


FIG. 3

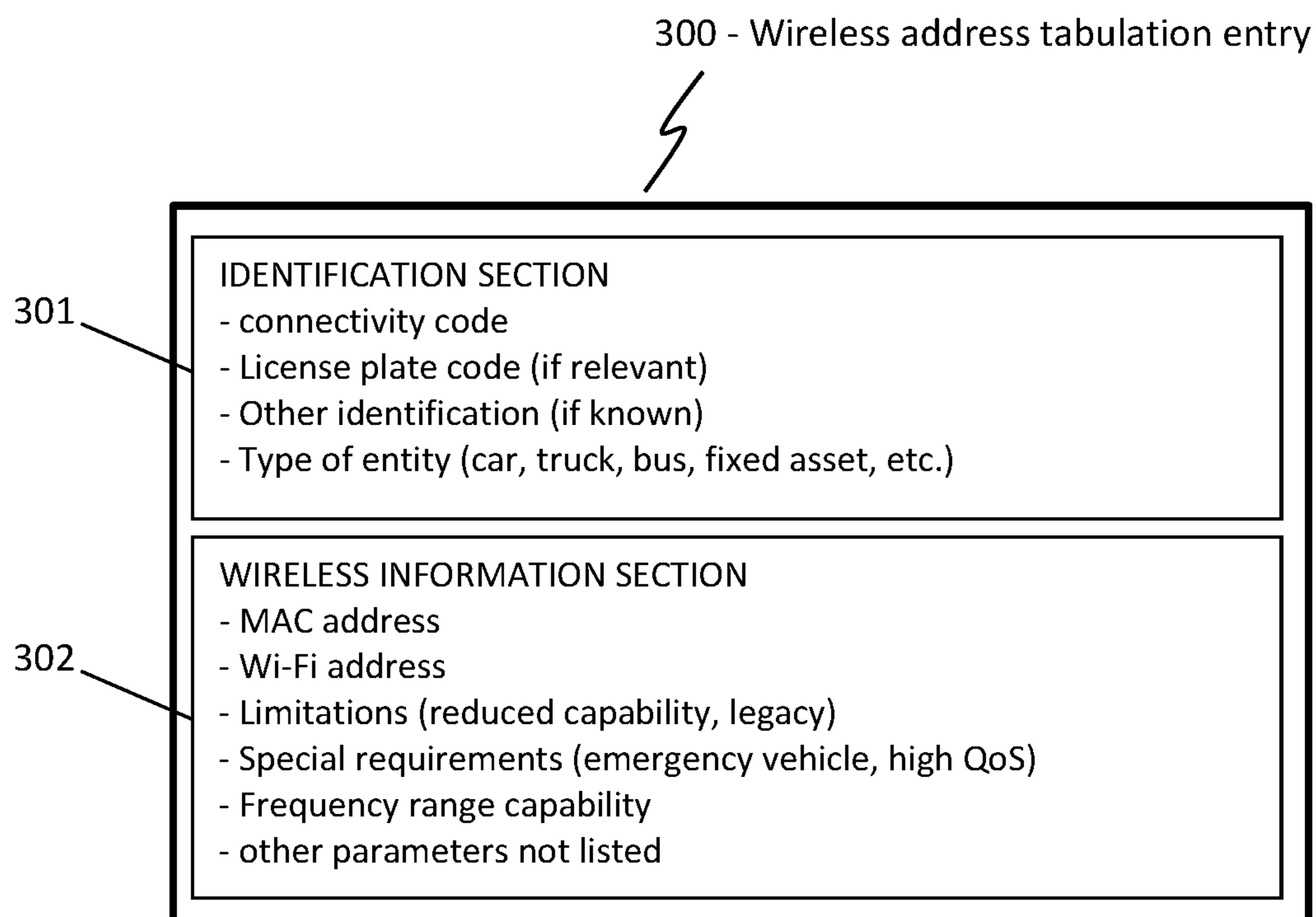


FIG. 4

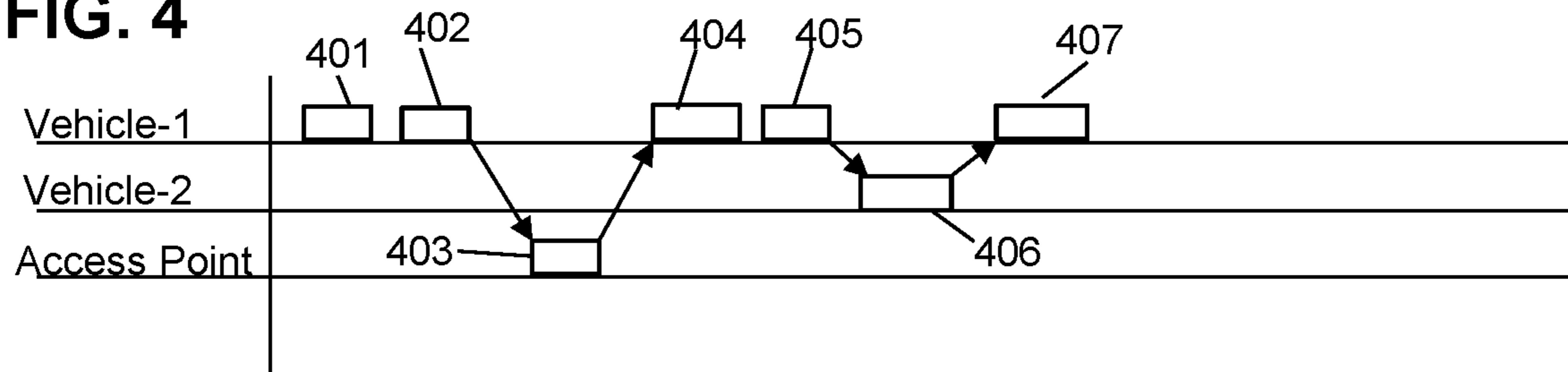


FIG. 5A

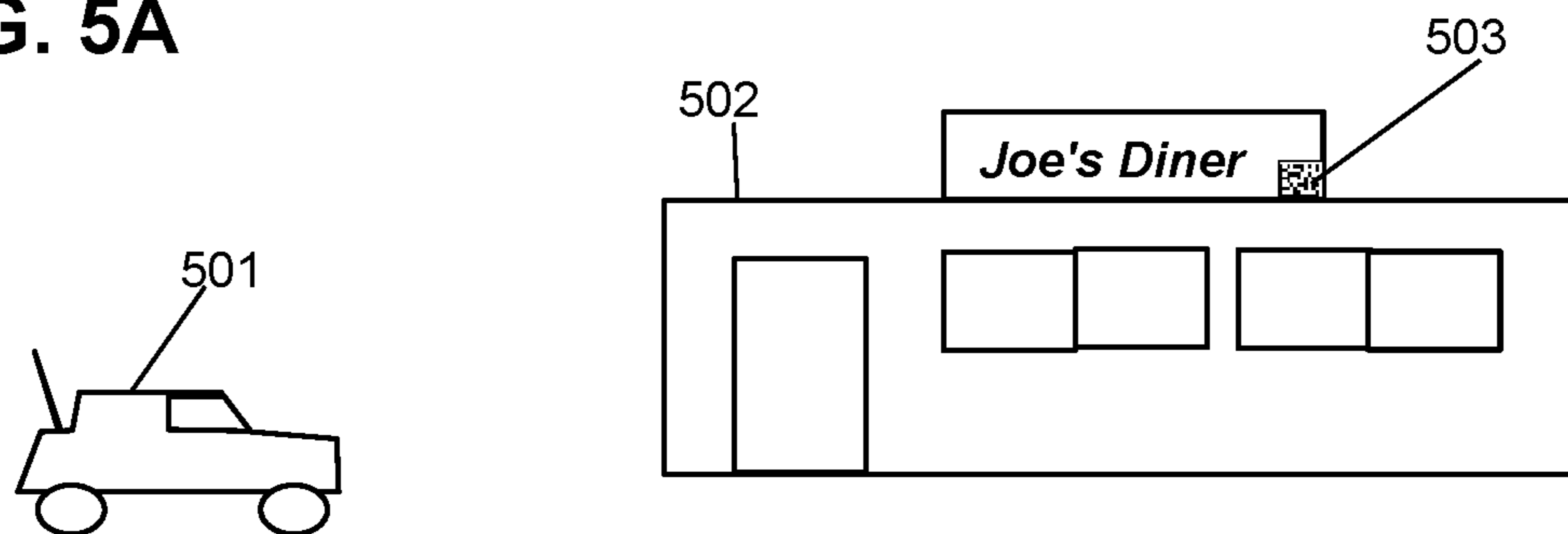


FIG. 5B

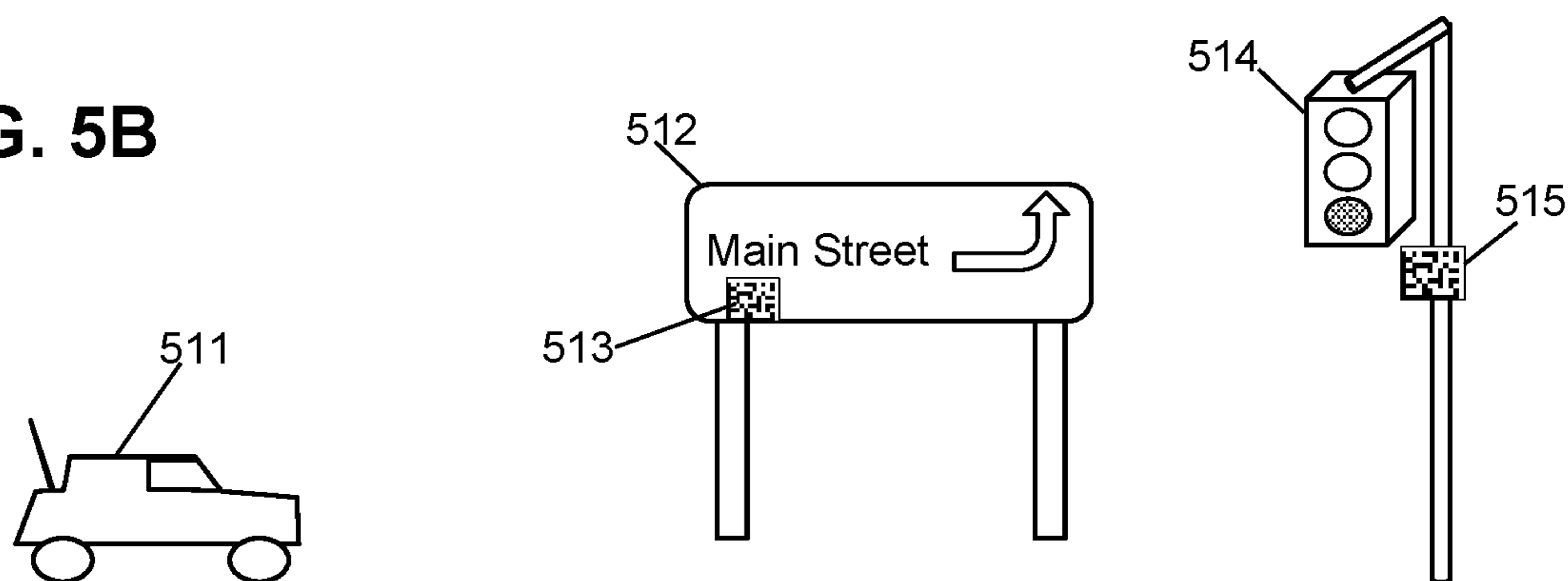


FIG. 5C

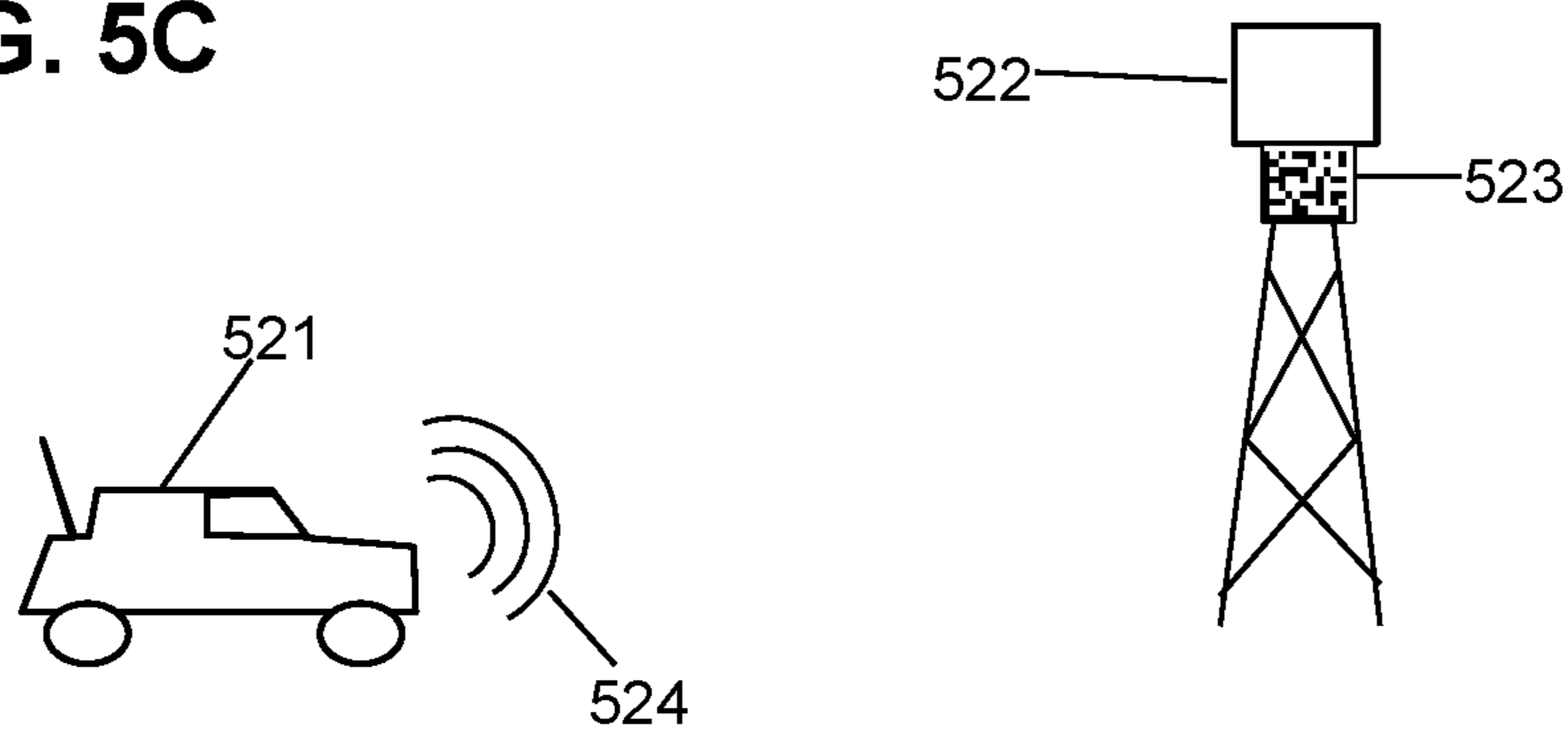


FIG. 6A

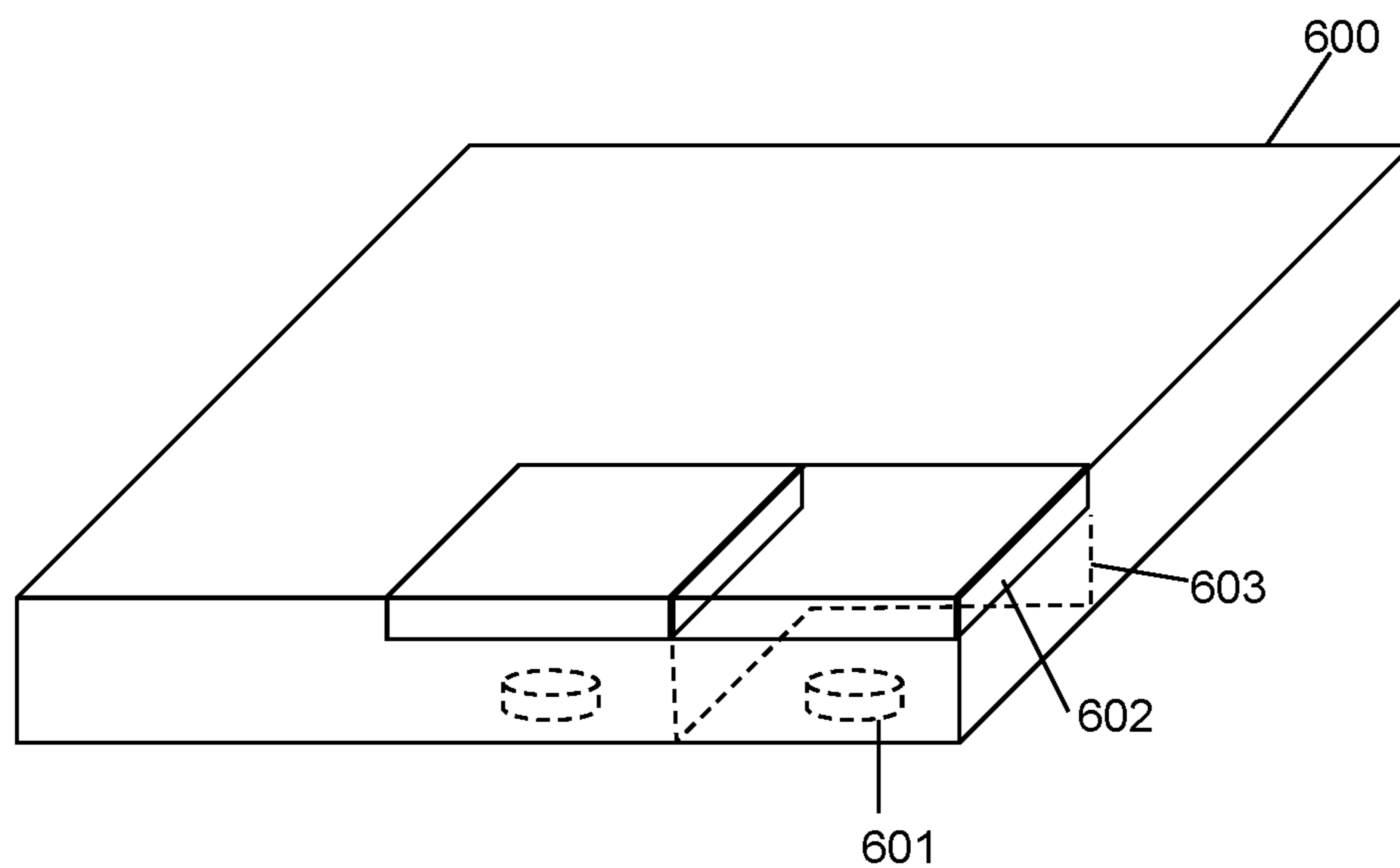
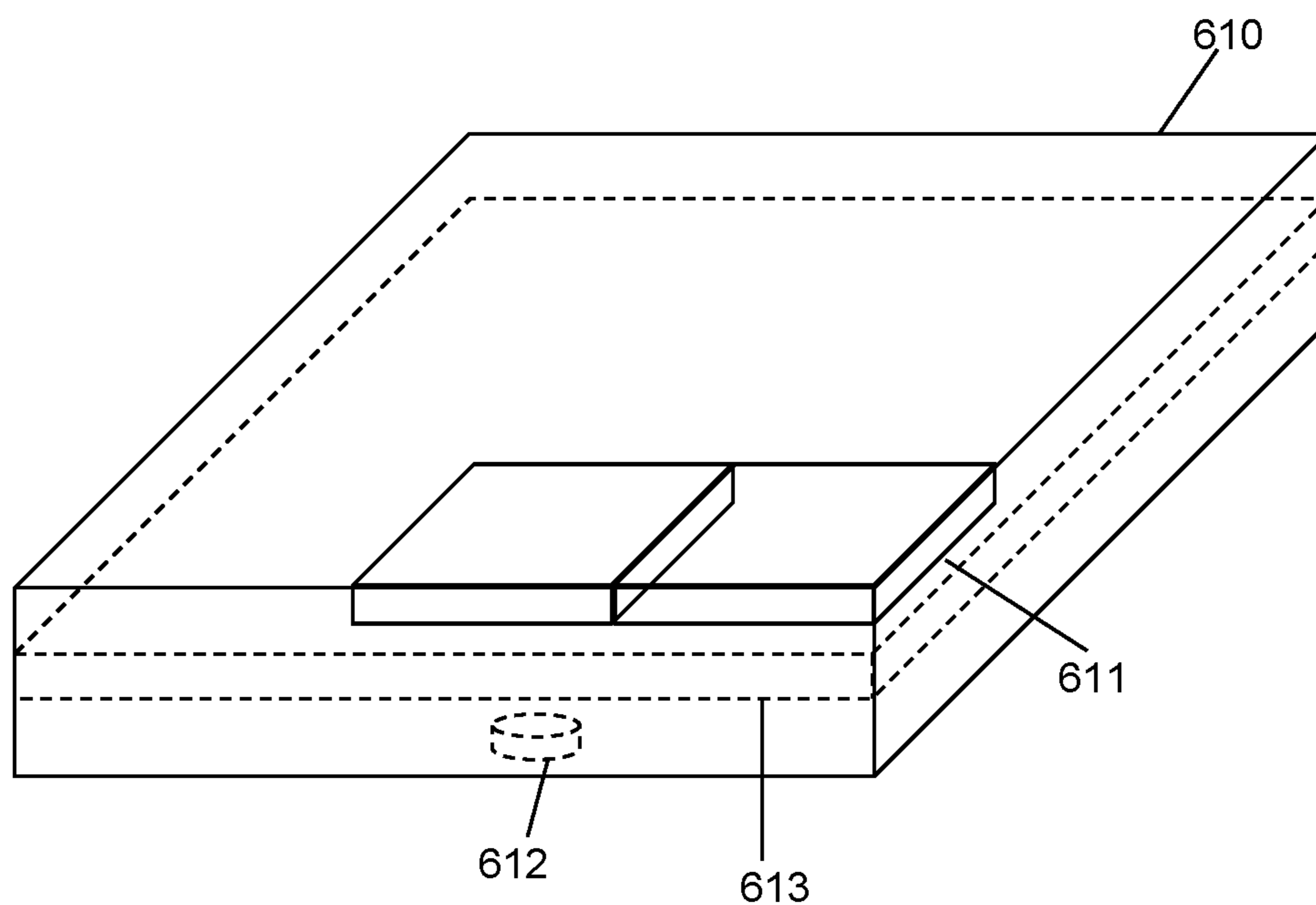


FIG. 6B



**V2V AND V2X COMMUNICATIONS IN 5G
AND 6G BASED ON DISPLAYED MATRIX**

**PRIORITY CLAIMS AND RELATED
APPLICATIONS**

[0001] This application is a continuation of U.S. patent application Ser. No. 17/875,919, entitled “Connectivity Matrix for Rapid 5G/6G Wireless Addressing”, filed Jul. 28, 2022, which is a continuation of U.S. patent application Ser. No. 17/583,395, entitled “Vehicle Connectivity, V2X Communication, and 5G/6G Sidelink Messaging”, filed Jan. 25, 2022, which claims the benefit of U.S. Provisional Patent Application Ser. No. 63/260,814, entitled “Localization and Identification of Vehicles in Traffic by 5G Messaging”, filed Sep. 1, 2021, and U.S. Provisional Patent Application Ser. No. 63/243,437, entitled “V2X Messaging in 5G with Simultaneous GPS Reception”, filed Sep. 13, 2021, and U.S. Provisional Patent Application Ser. No. 63/245,227, entitled “V2X with 5G Image Exchange and AI-Based Viewpoint Fusion”, filed Sep. 17, 2021, and U.S. Provisional Patent Application Ser. No. 63/246,000, entitled “V2X Connectivity Matrix with 5G Sidelink”, filed Sep. 20, 2021, and U.S. Provisional Patent Application Ser. No. 63/256,042, entitled “Hailing Procedure for V2R, V2V and V2X Initial Contact in 5G”, filed Oct. 15, 2021, and U.S. Provisional Patent Application Ser. No. 63/271,335, entitled “Semaphore Messages for Rapid 5G and 6G Network Selection”, filed Oct. 25, 2021, and U.S. Provisional Patent Application Ser. No. 63/272,352, entitled “Sidelink V2V, V2X, and Low-Complexity IoT Communications in 5G and 6G”, filed Oct. 27, 2021, and U.S. Provisional Patent Application Ser. No. 63/287,428, entitled “V2X and Vehicle Localization by Local Map Exchange in 5G/6G”, filed Dec. 8, 2021, and U.S. Provisional Patent Application Ser. No. 63/288,237, entitled “V2X with 5G/6G Image Exchange and AI-Based Viewpoint Fusion”, filed Dec. 10, 2021, and U.S. Provisional Patent Application Ser. No. 63/288,807, entitled “V2X Messaging in 5G/6G with Simultaneous GPS Reception”, filed Dec. 13, 2021, and U.S. Provisional Patent Application Ser. No. 63/290,731, entitled “Vehicle Connectivity, V2X Communication, and 5G/6G Sidelink Messaging”, filed Dec. 17, 2021, all of which are hereby incorporated by reference in their entireties.

FIELD OF THE INVENTION

[0002] The invention relates to systems and methods for localizing, identifying, and communicating with vehicles in traffic and fixed assets.

BACKGROUND OF THE INVENTION

[0003] Autonomous vehicles in traffic can cooperate, for collision avoidance and traffic efficiency, after determining the wireless address of the other vehicles. However, the wireless addresses of passing vehicles are generally unknown. Mobile entities often need to communicate specifically with fixed assets in view, which requires knowing which wireless address belongs to which vehicle. What is needed is means for determining the wireless address of specific entities in proximity.

[0004] This Background is provided to introduce a brief context for the Summary and Detailed Description that follow. This Background is not intended to be an aid in determining the scope of the claimed subject matter nor be

viewed as limiting the claimed subject matter to implementations that solve any or all of the disadvantages or problems presented above.

SUMMARY OF THE INVENTION

[0005] In a first aspect, there is non-transitory computer-readable media containing instructions that, when executed by a computing environment, cause a method to be performed, the method comprising: maintaining, in further non-transitory computer-readable media, a tabulation of entries, each entry comprising an index value and a wireless address of a vehicle or a fixed asset; receiving a request message specifying a code, wherein the code is indicated by a matrix comprising black and white rectangular fields visibly displayed by a particular vehicle or fixed asset; determining a particular index value according to the code; selecting a particular entry of the tabulation according to the particular index value; determining a particular wireless address comprising the particular entry; and transmitting a reply message indicating the particular wireless address.

[0006] In another aspect, there is a method for a first vehicle, in traffic comprising a second vehicle, the method comprising: observing, using a camera or sensor in or on the first vehicle, a matrix displayed by the second vehicle, the matrix comprising a plurality of fields colored black or white according to a binary code; determining the binary code of the matrix; determining an entry in a tabulation, the entry associated with the code; determining, according to the entry, a wireless address of the second vehicle; and transmitting a wireless message, according to the wireless address, to the second vehicle.

[0007] In another aspect, there is a system comprising a blockchain comprising information about wireless addresses, wherein: a first wireless entity comprises a camera, a processor, and a first matrix of black and white rectangular fields; the black and white rectangular fields are configured to display a first code associated with the first wireless entity; the camera is configured to image a second matrix displayed by a second wireless entity; the processor is configured to determine, according to the second matrix, a second code associated with the second wireless entity; and the processor is further configured to determine, according to the blockchain, a second wireless address associated with the second code.

[0008] This Summary is provided to introduce a selection of concepts in a simplified form. The concepts are further described in the Detailed Description section. Elements or steps other than those described in this Summary are possible, and no element or step is necessarily required. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended for use as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all disadvantages noted in any part of this disclosure.

[0009] These and other embodiments are described in further detail with reference to the figures and accompanying detailed description as provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1A is a schematic sketch of an exemplary embodiment of a computer-readable wireless identification matrix, according to some embodiments.

[0011] FIG. 1B is a schematic sketch of another exemplary embodiment of a computer-readable wireless identification matrix, according to some embodiments.

[0012] FIG. 1C is a schematic sketch of an exemplary embodiment of computer-readable wireless identification matrix on vehicles, according to some embodiments.

[0013] FIG. 2A is a schematic sketch of an exemplary embodiment of a wireless address tabulation, according to some embodiments.

[0014] FIG. 2B is a schematic sketch of another exemplary embodiment of a wireless address tabulation, according to some embodiments.

[0015] FIG. 3 is a schematic showing an exemplary embodiment of a single entry in a wireless address tabulation, according to some embodiments.

[0016] FIG. 4 is a sequence chart showing an exemplary embodiment of a procedure for a vehicle to initiate wireless communication with another vehicle, according to some embodiments.

[0017] FIG. 5A is a schematic sketch showing an exemplary embodiment of a fixed-asset application, according to some embodiments.

[0018] FIG. 5B is a schematic sketch showing an exemplary embodiment of a traffic sign with matrix, according to some embodiments.

[0019] FIG. 5C is a schematic sketch showing an exemplary embodiment of an access point with matrix, according to some embodiments.

[0020] FIG. 6A is a schematic sketch of an exemplary embodiment of a computer-readable matrix with illuminators, according to some embodiments.

[0021] FIG. 6B is a schematic sketch of another exemplary embodiment of a computer-readable matrix with illuminators, according to some embodiments.

[0022] Like reference numerals refer to like elements throughout.

DETAILED DESCRIPTION

[0023] Disclosed herein are 5G/6G procedures that enable autonomous and semi-autonomous vehicles to determine the wireless addresses of other autonomous vehicles and other items in traffic, using a low-cost computer-readable “connectivity matrix”, and optionally a tabulation of wireless addresses. Systems and methods disclosed herein (the “systems” and “methods”, also occasionally termed “embodiments” or “arrangements”, generally according to present principles) can provide urgently needed wireless communication protocols to provide specific wireless connectivity rapidly in traffic, thereby enabling cooperation and communication among vehicles and fixed assets. With such capabilities, vehicles can reduce traffic fatalities, facilitate traffic flow, and provide V2V and V2X communication options appropriate for 5G and 6G technologies, according to some embodiments.

[0024] Cooperation among autonomous vehicles in traffic depends on each vehicle being able to communicate specifically with a particular one of the other vehicles. However, this is possible only if the transmitting vehicle knows the wireless address of the other vehicle. In addition, a vehicle may advantageously communicate with a fixed asset on the land, but this also requires that the vehicle knows the associated frequency and wireless address. Furthermore, the fixed asset may need to initiate communication with the

vehicle, for example to warn the vehicle of a hazard, but must first determine the wireless address of the vehicle.

[0025] Beamforming has been considered as a method for communicating specifically with a single intended recipient. In beamforming, a complex antenna is configured to transmit a directional “beam” message toward the other vehicle. However, such beams inevitably have side-lobes which can spill over onto adjacent vehicles, especially in adjacent lanes. In addition, reflected energy from metallic conductors, such as vehicles, interfere with the primary beam and further complicate beam specificity. In addition, beam energy inevitably continues traveling beyond the intended recipient, and may then be received by other vehicles in the same direction.

[0026] The systems and methods described below can provide greater specificity at low cost. An entity such as a vehicle or fixed asset may display a “connectivity matrix”, a rectangular array of black and white fields encoding the wireless address and/or other data of the entity. Other wireless entities can determine the “connectivity code” according to the black and white fields, and thereby communicate specifically with the entity, according to some embodiments.

[0027] As used herein, a device or entity “knows” something if the device or entity has the relevant information. An “autonomous” vehicle is a vehicle operated by a processor, with little or no human control most of the time. A “semi-autonomous” vehicle is a vehicle at least partially operated by a processor, or which can be fully operated by a processor temporarily, such as during emergency intervention. A wireless message is “unicast” if it is addressed specifically to a particular recipient, and “broadcast” if it is transmitted without specifying a recipient. “V2V” means vehicle-to-vehicle messaging. “V2X” means vehicle-to-everything messaging. A “vehicle” is to be construed broadly, including any mobile conveyance such as cars, trucks, busses, motorcycles, scooters, and the like. “Entities” (such as wireless entities) as used herein represents systems or devices capable of wireless communication such as connected vehicles, pedestrians with smart phones, roadside access points or base stations, and so forth. “Fixed assets” include non-mobile objects that either include or are associated with a wireless transceiver. Wireless communication with a vehicle may include communicating with a processor in that vehicle, such as a processor connected to a wireless transceiver. Likewise a vehicle may transmit a message by causing the transceiver to transmit a message provided by the processor. A “sequence chart” is a chart showing actions of various entities versus time as boxes along horizontal lines, similar to an oscilloscope or logic analyzer display. Further terms will be defined as needed in examples.

[0028] Disclosed is a “computer-readable wireless identification matrix” or “connectivity matrix”, configured as a sign or emblem displayed visibly on a vehicle or other wireless entity. The connectivity matrix includes multiple black and white fields in a visible computer-readable array, encoding a “connectivity code” such as the entity’s wireless address and/or other information about the entity. For example, there may be a tabulation of wireless addresses arranged according to an index code, and the connectivity code may include that index. Another entity, reading the connectivity code, may then obtain the wireless address from the tabulation. In some embodiments, the connectivity matrix may be configured as a two-dimensional array of

black and white (or other contrasting) squares representing binary bits. The connectivity matrix may be formatted as a DataMatrix array, a QR type array, or other computer-readable representation of information. Usually the connectivity matrix is displayed exteriorly on a vehicle or other wireless entity. Other vehicles (or their cameras or other sensors) can readily view the matrix and record its bit-level content. By reading or viewing or recording the connectivity matrix, with sufficient resolution to resolve the various black and white fields therein, a vehicle or other entity can determine the connectivity code displayed by the matrix. In some embodiments, the wireless address of the entity bearing the connectivity matrix is shown on the code directly. In other embodiments, the code is an index of a tabulation of entries, each entry containing the wireless address associated with that index value, among other information about the entity bearing the connectivity matrix. After finding the wireless address, the entities can then communicate specifically, thereby enabling V2V and V2X communication and intervehicle cooperation in traffic to avoid collisions and manage the traffic flow, according to some embodiments.

[0029] The connectivity matrix may be variable. In some embodiments, the connectivity matrix can be turned on and off. For example, when a driver switches from autonomous mode to human-operated mode, the processor is no longer in control of the vehicle, and therefore communication on its wireless address would be futile. Accordingly, the connectivity matrix may be turned off, or rendered non-visible, to avoid sending conflicting information to other vehicles. For example, the white fields in the connectivity matrix may be illuminated by small light emitters such as white LEDs (light-emitting diodes), which may be turned off when the vehicle is switched to non-autonomous mode (thus rendering the connectivity matrix all black) and switched on when in autonomous mode. Alternatively, if the vehicle retains an emergency intervention capability while in human-operated mode, then the connectivity matrix may be left on during that time, so that other vehicles can trigger the emergency intervention when necessary to avoid a traffic hazard, for example. In addition, the connectivity code may be changed by programming a different set of LEDs to be illuminated, thereby updating the code or the wireless address displayed on the connectivity matrix, according to some embodiments.

[0030] Also disclosed is a “wireless address tabulation”, which is a file or database or other collection of information, organized as a number of entries, each entry corresponding to a particular index value, which may be indicated by a connectivity code. Each entry of the tabulation includes a wireless address associated with each connectivity code. Each entry may also include data about a particular autonomous vehicle or other wireless entity. For example, the data in a particular entry, associated with a particular connectivity code, may include the wireless address of the entity that holds a matrix displaying that particular connectivity code. For example, the entity may be a vehicle or a fixed asset or other device or system configured for wireless communication. In some embodiments, each entry of the wireless address tabulation may provide the wireless address, such as the MAC (media access control) address, of the vehicle or entity holding the associated connectivity code. Other parameters, such as frequencies and bandwidths and default modulations, may also be included, according to some embodiments.

[0031] In an embodiment, the tabulation of wireless addresses may be publicly accessible on, for example, the Internet and/or other on-line compilations of information. Members of the general public may be able to download, or otherwise copy, the wireless address tabulation, or regional portions thereof. Using such a copy, a vehicle or other entity can look up the wireless address of another vehicle or entity that displays a connectivity matrix. By reading the connectivity code displayed on the matrix, and then selecting the associated entry in the wireless address tabulation, the wireless address and other information about the entity displaying the connectivity matrix may be obtained. For example, a first vehicle may copy or otherwise obtain the wireless address tabulation, or a portion thereof, and may retain it in a memory. The first vehicle may view a second vehicle in traffic, and may read the connectivity code on a connectivity matrix displayed by the second vehicle. The first vehicle may then find, in the copied wireless address tabulation, an entry corresponding to that connectivity code, and may read the wireless address contained in that entry. The first vehicle can then communicate with the second vehicle by transmitting a message using the second vehicle’s wireless address, as determined from the tabulation, according to some embodiments.

[0032] In another embodiment, a vehicle may determine another vehicle’s wireless address without possessing a copy of the wireless address tabulation. For example, a first vehicle in traffic may view a second vehicle’s connectivity matrix and read the code therein. The first vehicle may then transmit an interrogation message to a remote address or site (such as an Internet site) operated by a connectivity manager. The request message may specify the connectivity code and may request the associated wireless address. The connectivity manager may then reply with that wireless address. The connectivity manager may be an entity tasked with maintaining the wireless address tabulation, and may provide wireless addresses responsive to such requests, for example. The connectivity manager may also provide other data such as publicly available identification data, such as the license plate of the vehicle associated with that connectivity code. The connectivity manager may be a government agency, a publicly funded corporation, an international organization, or other entity. If the message requests just the wireless address associated with the specified connectivity code, then the manager may reply with that address. If the message requests the entire entry associated with the specified connectivity code, the manager may provide the entire entry, according to some embodiments.

[0033] In another embodiment, a fixed asset such as a roadside device or building may display a connectivity matrix showing the wireless address of that fixed asset. For example, a network asset may display a connectivity matrix showing its main address or frequency on which new users may connect with the network. The connectivity code may indicate how new users can obtain system information from that network asset and begin registering on the network. For example, the connectivity code may indicate a frequency of the base station’s broadcast channel on which system information is periodically transmitted, thereby avoiding a tedious blind search and other steps in gaining registration, according to some embodiments.

[0034] In another embodiment, the connectivity matrix may be variable. The connectivity matrix structure may include illuminators and/or variable fields, so that the con-

nectivity code may be changed when necessary, and turned off when not in use. For example, each white field may be illuminated by a small white LED, and the connectivity code determines which of the LEDs are illuminated. Alternatively, the black and white fields may be controlled by solid-state shutters such as liquid-crystal squares that can be changed from opaque to transparent by applying a voltage. The connectivity code can then be changed by changing which voltage is applied to each of the fields. The matrix may be back-illuminated by, for example, built-in light emitters, or it may use ambient light for contrast between the light and dark fields, according to some embodiments.

[0035] In some embodiments, a first vehicle in traffic can determine the wireless address of a second vehicle by reading the second vehicle's connectivity matrix using, for example, a camera. The first vehicle can then transmit a unicast message addressed exclusively to the second vehicle using, for example, a sidelink channel or other frequency allocated for V2V or V2X communication. The wireless messages may be transmitted according to 5G or 6G sidelink specifications. For example, if an access point or base station is within range, the communication may be transmitted according to 5G/6G sidelink "mode-1", in which the base station sets the timing and manages the vehicle messages. If no network interface is available, the vehicles may set up a "mode-2" sidelink network in which the timing and bandwidths are managed by the vehicles themselves. Alternatively, the vehicles may transmit their messages according to another technology such as Wi-Fi or transmitting at-will, for example.

[0036] In some embodiments, the connectivity code can indicate further information about the vehicle or entity bearing the connectivity matrix, such as whether the vehicle is autonomous, semi-autonomous, or exclusively human-operated. Alternatively, that information may be included in the vehicle's entry in the wireless address tabulation. Thus a first vehicle may read the connectivity code of a second vehicle and transmit a message to the second vehicle indicating the first vehicle's wireless address, so that the second vehicle can then send other messages to the first vehicle unicast. In some embodiments, the first vehicle can include, in its message to the second vehicle, information indicating the first vehicle's physical position relative to the second vehicle, so that the second vehicle can determine which of the proximate vehicles is transmitting the message. For example, the first vehicle's message may include data indicating that the first vehicle is "35 meters behind you and one lane to the left", and sensors on the second vehicle can view the first vehicle accordingly. The vehicles can then associate the other vehicle's wireless address with the particular vehicle observed, and can follow or track each other as they move in traffic.

[0037] In some embodiments, vehicles in traffic may be configured to obtain the wireless addresses of proximate vehicles proactively. For example a first vehicle may look up the wireless addresses of other vehicles that display a connectivity matrix, as soon as they come into view, and this may be done automatically even when there is no message to send. Then, if an emergency suddenly arises, the first vehicle can initiate communication with the other vehicles immediately, saving valuable time.

[0038] Examples described below provide further details about certain exemplary embodiments of the present principles.

[0039] FIG. 1A is a schematic sketch of an exemplary embodiment of a computer-readable wireless identification matrix, according to some embodiments. As depicted in this non-limiting example, the connectivity matrix **100** may include a plurality of black and white (or other contrasting color), nominally square, adjacent fields in a rectangular or square array, each field colored to indicate one binary bit of a connectivity code. For example, black may represent binary "0" and white may represent binary "1", or vice-versa. The depicted example is formatted as a DataMatrix array including 48 information bits surrounded by a black and white orientation border (black on left and bottom borders, alternating black and white across the top and right side). Other two-dimensional formats, such as QR (Quick Response) code, Aztec code, Trillcode, Quickmark, Shotcode, mCode, and one-dimensional formats, such as UPC or BarCode, and special fonts such as Check Font may be used instead. The 48-bit code may be the vehicle's MAC address, for example. Other vehicles, detecting the connectivity matrix **100** using sensors, and reading the 48-bit code using a camera for example, may thereby determine that vehicle's wireless address and may then communicate specifically with that vehicle. For example, a first vehicle in traffic may detect an imminent collision with a second vehicle in front, and may read the second vehicle's connectivity matrix **100**, thereby determining the second vehicle's wireless address. The first vehicle may then transmit an emergency message to the second vehicle asking it to speed up quickly, to avoid a collision. In this way, the connectivity matrix **100** may enable cooperative actions by vehicles in traffic, and may thereby prevent or mitigate collisions, saving countless lives, according to some embodiments.

[0040] FIG. 1B is a schematic sketch of another exemplary embodiment of a computer-readable wireless identification matrix, according to some embodiments. As depicted in this non-limiting example, a larger connectivity matrix **101** includes 100 data squares surrounded by an orientation border. The connectivity matrix **101** may be affixed to a vehicle or other wireless entity, thereby allocating a unique 100-bit code to the entity. A vehicle may display the connectivity matrix on, for example, the front and back, and optionally also the sides, of the vehicle, so that other vehicles can view the pattern and read the code.

[0041] In some embodiments, a connectivity manager may be responsible for allocating the connectivity codes to various entities that request them. The connectivity manager may thereby maintain a wireless address tabulation in which each registered vehicle in the tabulation has an associated entry, the entry is associated with the vehicle's displayed connectivity code, each code is uniquely assigned, and duplicates are avoided. Each vehicle's entry in the wireless address tabulation may be a listing of that vehicle's allocated connectivity code along with its wireless address, and optionally other information of the vehicle or entity holding that code.

[0042] In some embodiments, when a first vehicle in traffic needs to transmit a message to a second vehicle displaying a connectivity matrix, the first vehicle can obtain the connectivity code from the matrix image, and then look up the second vehicle's wireless address corresponding to that connectivity code in a copy of the wireless address tabulation (or a portion thereof). Alternatively, if the first vehicle does not possess a copy of the wireless address tabulation, it may transmit a message to the connectivity manager

requesting the wireless address corresponding to the connectivity matrix, which the connectivity manager may then supply in a return message. As another alternative, the second vehicle's matrix may indicate, in the bit pattern, the wireless address of the second vehicle. In each case, the first vehicle can determine the wireless address of the second vehicle according to the connectivity code displayed by the second vehicle, and can then transmit a message specifically to the second vehicle using the second vehicle's wireless address. Optionally, the first vehicle may include its own wireless address in the message, so that the second vehicle can reply specifically to the first vehicle. Optionally, the connectivity manager may supply further data about the second vehicle, such as its license plate code, whether it is autonomous, and other wireless parameters, if requested.

[0043] In some embodiments, the wireless address tabulation may provide only publicly available information that vehicles in traffic may need to communicate V2V and V2X. The publicly available information may include readily visible information, such as the type and color of vehicle, its license plate, and other readily visible information. All other information, other than readily visible features and public information, may be considered private and may be excluded from the tabulation.

[0044] In some embodiments, an autonomous vehicle or a person or other entity may transmit a registration request message to the connectivity manager specifying the vehicle's MAC address, and the connectivity manager may set up an entry in the wireless address tabulation using a randomly selected connectivity code. The connectivity manager may include that wireless address in the entry, and may transmit the assigned connectivity code back to the vehicle. The connectivity matrix can then be printed, or otherwise fabricated, with the associated connectivity code.

[0045] In some embodiments, a vehicle or owner may register in the wireless address tabulation by specifying a particular connectivity code that the vehicle or owner wishes to use. For example, the desired code may include the vehicle's wireless address. If the requested code is available, the connectivity manager may generate an entry with that code as the index. The vehicle may then display a connectivity matrix with that code, so that other vehicles may read the code and determine the wireless address directly, without having to interrogate the connectivity manager or look up the entry in the wireless address tabulation. For example, the 48-bit MAC address may be encoded in a region of the connectivity matrix, and vehicles viewing the connectivity matrix may determine the wireless address of the vehicle without using a wireless address tabulation. As a particular and non-limiting embodiment, the first 24 bits may be encoded with the ASCII (American Standard Code for Information Interchange) code for "MAC", followed by the 48-bit MAC address of the vehicle's autonomous processor, followed by other information such as a frequency in the final 28 bits. In some embodiments, some of those bits may be allocated to error detection, such as parity bits.

[0046] In some embodiments, the wireless address obtained using the connectivity code or the wireless address tabulation may be an address code of a particular processor on that vehicle. For example, the address code may be the address of a message-entry processor connected to the wireless receiver in an autonomous or semi-autonomous vehicle. The message-entry processor may be configured to analyze incoming messages to detect malware or other

inappropriate messaging, and to protect the system against malicious intent. In some embodiments, the message-entry processor (or another processor in the vehicle) may include artificial intelligence (AI) configured to detect malicious messages, and to recognize and prioritize emergency messages and other types of legitimate wireless activity. For example, an AI structure such as a neural net may be trained by machine learning to discriminate different types of communications, thereby enabling a rapid cooperative response to a legitimate collision-avoidance request, while rejecting harmful or deceptive communication attempts. In addition, the message-entry processor may include an updating feature whereby the AI structure, or an algorithm derived from it for field use, may be revised periodically, using a secure on-line connection for example, to provide the most up-to-date malware detection algorithms. In addition, the message-entry processor may record messages that seem suspicious, and may upload those periodically to a central entity tasked with detecting new threat patterns.

[0047] FIG. 1C is a schematic sketch of an exemplary embodiment of computer-readable wireless identification matrix on vehicles, according to some embodiments. As depicted in this non-limiting example, a vehicle **110** is shown with a connectivity matrix **111** mounted on the back, and a second vehicle **120** with a connectivity matrix **121** on the front. In some embodiments, the connectivity matrices **111-121** are large enough that other vehicles, or their cameras or sensors, can detect the individual fields with high reliability, yet not so large to obscure other parts of the vehicle (the license plate, various lamps, the radiator screen, the trunk handle, for example). In some embodiments, the connectivity matrix is large enough to be resolved by cameras or sensors on vehicles at a distance corresponding to vehicle separations in traffic, such as 20 or 50 or 100 meters. In some embodiments, each black or white field is large enough to be readily viewed and resolved by other vehicles, such as each field being 5 or 10 or 20 mm in width and height.

[0048] FIG. 2A is a schematic sketch of an exemplary embodiment of a wireless address tabulation, according to some embodiments. As depicted in this non-limiting example, the wireless address tabulation **201** is depicted, quite schematically, as a paper containing entries **202**, each entry **202** corresponding to an assigned connectivity code. However, the wireless address tabulation **201** is envisioned as an electronic file or the like, not as a paper, unless someone wants to print it out. Also depicted are a first autonomous vehicle **203** bearing a first connectivity matrix **205**, and a second autonomous vehicle **204** with a second connectivity matrix **206**. In this embodiment, the connectivity matrices **205-206** are mounted on the sides of the vehicles **203-204**, while additional copies may be mounted on the front and back of the vehicles **203-204**, not shown.

[0049] In the example, the first vehicle **203** has downloaded the wireless address tabulation **201**, as indicated by an arrow **207**, and has stored it in non-transitory computer-readable media for mobile use, particularly when out of range of a network. Suddenly an emergency arises, and the first vehicle **203** needs to send a message **208** to the second vehicle **204**, enlisting its support for a collision avoidance maneuver. The first vehicle, using its camera, reads the code contained in the second vehicle's connectivity matrix **206** (if it has not already done so), then looks in the wireless address tabulation **201** for the entry corresponding to that code (if

not already done), and thereby determines the second vehicle's wireless address. The first vehicle **203** then transmits the message **208** to the second vehicle **204**, which the second vehicle **204** receives and, cooperating with the first vehicle **203**, avoids the imminent collision.

[0050] In another embodiment, the first vehicle **203** may be configured to read the connectivity codes of all vehicles as soon as they come into view, and determine their wireless addresses automatically, and store the address codes in memory until the second vehicle moves out of view or out of range. In that case, the first vehicle **203** may already know the second vehicle's wireless address when the emergency arises, thereby saving precious milliseconds.

[0051] In yet another embodiment, the second vehicle's connectivity matrix **206** may provide its wireless address directly encoded in the connectivity code, as shown in FIG. 1A for example. In that case, the first vehicle **203** does not need to refer to the wireless address tabulation **201**, but instead can read the wireless address directly from the second vehicle's connectivity matrix. The first vehicle **203** can then transmit the message **208** to the second vehicle **204** using that address, thereby avoiding the delay of interrogating the wireless address tabulation.

[0052] FIG. 2B is a schematic sketch of another exemplary embodiment of a wireless address tabulation, according to some embodiments. As depicted in this non-limiting example, a base station **231** or access point, depicted as an antenna, has previously obtained a copy of the wireless address tabulation **221**, as indicated by the arrow **227**. The wireless address tabulation **221** includes entries **222** associated with connectivity codes on vehicles. A first vehicle **223** displays a first connectivity matrix **225**, and a second vehicle **224** displays a second connectivity matrix **226**. An emergency arises, and sensors on the first vehicle **223** can read the second connectivity matrix **226** of the second vehicle **224**. Then, the first vehicle can transmit a wireless message **230** to the base station **231** including the data in the second connectivity matrix **226**. The message may include an image of the connectivity matrix or, much more compactly, the 100-bit value encoded therein. The base station **231** then finds the entry **232** corresponding to that connectivity code **226** and transmits the corresponding wireless address **229** back to the first vehicle **223**. The first vehicle **223** thereby determines the wireless address of the second vehicle **224**, and transmits a message **228** to the second vehicle **224**, enabling cooperating to avoid the collision.

[0053] In another embodiment, the first vehicle **223** may be configured to read the second vehicle's connectivity matrix **226**, interrogate the base station, receive the associated entry **229**, and thereby determine the second vehicle's wireless address before the emergency occurred, such as determining the wireless address as soon as the second vehicle comes into view. By checking the wireless addresses of proximate vehicles automatically, the first vehicle **223** may be able to initiate communications more rapidly than otherwise.

[0054] FIG. 3 is a schematic showing an exemplary embodiment of an entry of a wireless address tabulation, according to some embodiments. As depicted in this non-limiting example, the entry **300** may be associated with a particular connectivity code and a particular wireless address of a particular entity such as a vehicle. The entry **300** may include one or more sections, each section providing different information about the associated vehicle or entity.

In the depicted example, the entry **300** includes an identification section **301** including the connectivity code that the entry **300** corresponds to, and optionally the associated license plate code, the type of entity involved, and other public information if known. The entry **300** also includes a wireless information section **302** including the wireless address, such as the MAC address and/or a Wi-Fi address of the associated entity's processor, along with optionally any limitations or special requirements, among other information as available.

[0055] FIG. 4 is a sequence chart showing an exemplary embodiment of a procedure for a vehicle to initiate wireless communication with another vehicle, according to some embodiments. As depicted in this non-limiting example, actions of two vehicles are shown as boxes on horizontal lines, and actions of a base station or access point are shown on a third line. The horizontal axis represents time. Causation is indicated by tilted arrows accounting for the time delay of signals or actions. Vehicle-1 first views Vehicle-2 at **401** and determines the connectivity code displayed on Vehicle-2's matrix. Vehicle-1 transmits a request message **402** to a connectivity manager via the base station. The connectivity manager replies via the base station with a message **403** indicating the wireless address of Vehicle-2. Vehicle-1 receives the message **404** and then transmits an emergency message **405** to Vehicle-2. Vehicle-2 receives the message at **406** and responds with an acknowledgement **407** which Vehicle-1 receives. In this way, using the connectivity matrix and the remote wireless address tabulation, Vehicle-1 has established unicast communication with Vehicle-2.

[0056] In another embodiment, Vehicle-1 may download the wireless address tabulation from a portal, such as a base station, or from an Internet connection, or other link in communication with the connectivity manager. Then, upon viewing the connectivity matrix on Vehicle-2 and reading its connectivity code, Vehicle-1 may look up the corresponding entry in its copy of the wireless address tabulation, and may thereby determine the wireless address of Vehicle-2, and proceed to communicate with Vehicle-2.

[0057] In yet another embodiment, Vehicle-2's connectivity code may include an indication of its wireless address, in which case Vehicle-1 may initiate communication with Vehicle-2 upon reading Vehicle-2's matrix, instead of looking for the entry in the wireless address tabulation.

[0058] FIG. 5A is a schematic sketch showing an exemplary embodiment of a fixed-asset application, according to some embodiments. As depicted in this non-limiting example, a vehicle **501** such as an autonomous vehicle approaches a fixed asset depicted as a business site **502** which displays a connectivity matrix **503**. Upon coming into view of the business **502**, the vehicle **501** may read the matrix **503**, and determine the wireless address of the business **502**, or more specifically, the wireless address of a transceiver in the business **502**. The vehicle **501** may then transmit a message to the business **502** such as "Is the fish fresh today?".

[0059] FIG. 5B is a schematic sketch showing an exemplary embodiment of a traffic sign, according to some embodiments. As depicted in this non-limiting example, a vehicle **511** approaches a street sign **512** with a connectivity matrix **513** indicating a wireless address. For example, the matrix **513** may indicate the wireless address of a site that provides directions to vehicles that are lost, or other infor-

mation. For example, the vehicle **511** may transmit a message asking, for example, “Does Maple Avenue cross Main Street?”.

[0060] Also shown is a traffic signal **514** with another connectivity matrix **515**. The vehicle **511** may read the matrix **515**, determine a wireless address associated with the traffic signal **514**, and transmit a message to it, such as “How long until you change to green?” or “I am a physician and this is an emergency.”

[0061] FIG. **5C** is a schematic sketch showing an exemplary embodiment of an access point with a connectivity matrix, according to some embodiments. As depicted in this non-limiting example, a vehicle **521** is in view of a base station **522** or access point depicted as an antenna with an associated connectivity matrix **523**. The matrix **523** may provide an identity that enables the vehicle **521** to obtain, from a wireless address tabulation, the login frequency of the base station **522**. The base station’s entry in a wireless address tabulation may also include system information needed to register on that base station **522**, such as frequencies and bandwidths and network parameters specific to that base station **522**, so that the vehicle **521** can then transmit a message **524** and register with the base station **522** without performing complex 5G/6G protocols to find that information. For example, the connectivity matrix **523** may indicate the broadcast frequency of the base station **522** on which the base station **522** transmits system information. The entry may indicate how a user device can communicate with the base station, including specifying one or more additional frequencies or channels on which further system information may be transmitted. In addition, the entry may indicate a frequency or channel on which the user device can transmit a message to the base station, such as a “random access preamble” message requesting registration on that base station, according to some embodiments.

[0062] FIG. **6A** is a schematic sketch of an exemplary embodiment of a computer-readable connectivity matrix with illuminators, according to some embodiments. As depicted in this non-limiting example, an illuminated variable connectivity matrix **600** may include, in each field of the matrix **600**, an illuminator **601** (dashed, interior) such as an LED, an opaque separator **603**, and optionally a diffuser **602**. The LEDs **601** may be powered according to the connectivity code, with the LEDs **601** powered in the white fields and unpowered in the black fields. Illumination may enhance visibility, especially at night. In addition, the connectivity code may be changed by powering different LEDs **601**. In addition, the connectivity matrix **600** may be turned off (rendered all black) by depowering all of the LEDs **601**.

[0063] FIG. **6B** is a schematic sketch of another exemplary embodiment of a computer-readable connectivity matrix with illuminators, according to some embodiments. As depicted in this non-limiting example, a connectivity matrix **610** may include a variable-transmissive window **611** such as a liquid-crystal film for each field of the matrix, connected to a voltage source (not shown) configured to control whether the window **611** is transparent or opaque. In addition, one or more illuminators **612** may be mounted behind an optional diffuser **613** for back-illuminating the various windows **611**. By arranging voltages to the various windows **611**, the connectivity matrix **610** may be altered to show different codes, and may be turned off by depowering the illuminators **612**. For enhanced visibility at night, a

reflective backing such as a retro-reflective film (not shown) may be included to reflect incoming light.

[0064] The wireless embodiments of this disclosure may be aptly suited for cloud backup protection, according to some embodiments. Furthermore, the cloud backup can be provided cyber-security, such as blockchain, to lock or protect data, thereby preventing malevolent actors from making changes. The cyber-security may thereby avoid changes that, in some applications, could result in hazards including lethal hazards, such as in applications related to traffic safety, electric grid management, law enforcement, or national security.

[0065] In some embodiments, non-transitory computer-readable media may include instructions that, when executed by a computing environment, cause a method to be performed, the method according to the principles disclosed herein. In some embodiments, the instructions (such as software or firmware) may be upgradable or updatable, to provide additional capabilities and/or to fix errors and/or to remove security vulnerabilities, among many other reasons for updating software. In some embodiments, the updates may be provided monthly, quarterly, annually, every 2 or 3 or 4 years, or upon other interval, or at the convenience of the owner, for example. In some embodiments, the updates (especially updates providing added capabilities) may be provided on a fee basis. The intent of the updates may be to cause the updated software to perform better than previously, and to thereby provide additional user satisfaction.

[0066] The system and method may be fully implemented in any number of computing devices. Typically, instructions are laid out on computer readable media, generally non-transitory, and these instructions are sufficient to allow a processor in the computing device to implement the method of the invention. The computer readable medium may be a hard drive or solid state storage having instructions that, when run, or sooner, are loaded into random access memory. Inputs to the application, e.g., from the plurality of users or from any one user, may be by any number of appropriate computer input devices. For example, users may employ vehicular controls, as well as a keyboard, mouse, touch-screen, joystick, trackpad, other pointing device, or any other such computer input device to input data relevant to the calculations. Data may also be input by way of one or more sensors on the vehicle, an inserted memory chip, hard drive, flash drives, flash memory, optical media, magnetic media, or any other type of file—storing medium. The outputs may be delivered to a user by way of signals transmitted to vehicle steering and throttle controls, a video graphics card or integrated graphics chipset coupled to a display that maybe seen by a user. Given this teaching, any number of other tangible outputs will also be understood to be contemplated by the invention. For example, outputs may be stored on a memory chip, hard drive, flash drives, flash memory, optical media, magnetic media, or any other type of output. It should also be noted that the invention may be implemented on any number of different types of computing devices, e.g., embedded systems and processors, personal computers, laptop computers, notebook computers, net book computers, handheld computers, personal digital assistants, mobile phones, smart phones, tablet computers, and also on devices specifically designed for these purpose. In one implementation, a user of a smart phone or WiFi-connected device downloads a copy of the application to their device from a server using a wireless Internet connection. An

appropriate authentication procedure and secure transaction process may provide for payment to be made to the seller. The application may download over the mobile connection, or over the WiFi or other wireless network connection. The application may then be run by the user. Such a networked system may provide a suitable computing environment for an implementation in which a plurality of users provide separate inputs to the system and method. In the below system where vehicle controls are contemplated, the plural inputs may allow plural users to input relevant data at the same time.

[0067] It is to be understood that the foregoing description is not a definition of the invention but is a description of one or more preferred exemplary embodiments of the invention. The invention is not limited to the particular embodiments(s) disclosed herein, but rather is defined solely by the claims below. Furthermore, the statements contained in the foregoing description relate to particular embodiments and are not to be construed as limitations on the scope of the invention or on the definition of terms used in the claims, except where a term or phrase is expressly defined above. Various other embodiments and various changes and modifications to the disclosed embodiment(s) will become apparent to those skilled in the art. For example, the specific combination and order of steps is just one possibility, as the present method may include a combination of steps that has fewer, greater, or different steps than that shown here. All such other embodiments, changes, and modifications are intended to come within the scope of the appended claims.

[0068] As used in this specification and claims, the terms “for example”, “e.g.”, “for instance”, “such as”, and “like” and the terms “comprising”, “having”, “including”, and their other verb forms, when used in conjunction with a listing of one or more components or other items, are each to be construed as open-ended, meaning that the listing is not to be considered as excluding other additional components or items. Other terms are to be construed using their broadest reasonable meaning unless they are used in a context that requires a different interpretation.

1. Non-transitory computer-readable media containing instructions that, when executed by a computing environment, cause a method to be performed, the method comprising:

- a) maintaining, in further non-transitory computer-readable media, a tabulation of entries, each entry comprising an index value and a wireless address of a vehicle or a fixed asset;
- b) receiving a request message specifying a code, wherein the code is indicated by a matrix comprising black and white rectangular fields visibly displayed by a particular vehicle or fixed asset;
- c) determining a particular index value according to the code;
- d) selecting a particular entry of the tabulation according to the particular index value;
- e) determining a particular wireless address comprising the particular entry; and
- f) transmitting a reply message indicating the particular wireless address.

2. The non-transitory computer-readable media of claim 1, wherein the reply message is transmitted according to 5G or 6G technologies.

3. The non-transitory computer-readable media of claim 1, the method further comprising:

- a) determining that the request message indicates that the particular entry should be transmitted in entirety; and
 - b) transmitting, in the reply message, the particular entry in entirety.
4. The non-transitory computer-readable media of claim 1, the method further comprising:
- a) determining that the request message indicates that only the particular wireless address should be transmitted; and
 - b) transmitting, in the reply message, the particular wireless address without transmitting other information, if any, comprising the particular entry.
5. The non-transitory computer-readable media of claim 1, the method further comprising:
- a) receiving, from the particular vehicle or fixed asset, a change message, the change message specifying the code and providing additional or changed information;
 - b) determining a particular index according to the code;
 - c) determining a particular entry according to the particular index; and
 - d) revising the particular entry according to the additional or changed information.
6. The non-transitory computer-readable media of claim 1, the method further comprising:
- a) receiving a joining message from a new vehicle or fixed asset, wherein the new vehicle or fixed asset is not associated with any entry in the tabulation;
 - b) determining that the joining message specifies a wireless address of the new vehicle or fixed asset, and requests that a new entry be added to the tabulation;
 - c) generating the new entry in the tabulation, the new entry comprising the wireless address of the new vehicle or fixed asset;
 - d) determining a new index value, and associating the new entry with the new index value;
 - e) generating a new code according to the new index value; and
 - f) transmitting a welcome message to the new vehicle or fixed asset, the welcome message indicating the new code.
7. The non-transitory computer-readable media of claim 1, wherein:
- a) the joining message further indicates a frequency and a bandwidth; and
 - b) the new entry further comprises the frequency and the bandwidth.
8. The non-transitory computer-readable media of claim 1, wherein:
- a) the joining message further indicates an MCS (modulation and coding scheme); and
 - b) the new entry further comprises the MCS.
9. The non-transitory computer-readable media of claim 1, wherein:
- a) the joining message further indicates one or more capabilities or limitations of the new vehicle or fixed asset; and
 - b) the new entry further comprises the one or more capabilities or limitations of the new vehicle or fixed asset.
10. A method for a first vehicle, in traffic comprising a second vehicle, the method comprising:
- a) observing, using a camera or sensor in or on the first vehicle, a matrix displayed by the second vehicle, the

- matrix comprising a plurality of fields colored black or white according to a binary code;
- b) determining the binary code of the matrix;
 - c) determining an entry in a tabulation, the entry associated with the code;
 - d) determining, according to the entry, a wireless address of the second vehicle; and
 - e) transmitting a wireless message, according to the wireless address, to the second vehicle.
- 11.** The method of claim **10**, wherein:
- a) the code comprises a predetermined number of code bits;
 - b) the matrix comprises a plurality of border fields surrounding a plurality of data fields; and
 - c) the number of code bits equals a number of data fields.
- 12.** The method of claim **10**, further comprising:
- a) determining, according to the entry, a frequency and a bandwidth; and
 - b) transmitting the wireless message according to the frequency and the bandwidth.
- 13.** The method of claim **10**, further comprising:
- a) determining, according to the entry, an MCS (modulation and coding scheme); and
 - b) transmitting the wireless message according to the MCS.
- 14.** The method of claim **10**, further comprising:
- a) determining, according to the matrix, whether the second vehicle is autonomously driven or human-driven.
- 15.** The method of claim **10**, further comprising:
- a) displaying, on the first vehicle, a further matrix comprising a plurality of fields colored black or white according to a further binary code;
 - b) wherein the further binary code is associated with a further entry in the tabulation, and the further entry comprises a further wireless address of the first vehicle.

- 16.** The method of claim **15**, further comprising:
- a) turning off the further matrix, by depowering illuminators in the further matrix, while the first vehicle is human-operated; and
 - b) turning on the further matrix, by repowering the illuminators in the further matrix, while the first vehicle is computer-operated.
- 17.** A system comprising a blockchain comprising information about wireless addresses, wherein:
- a) a first wireless entity comprises a camera, a processor, and a first matrix of black and white rectangular fields;
 - b) the black and white rectangular fields are configured to display a first code associated with the first wireless entity;
 - c) the camera is configured to image a second matrix displayed by a second wireless entity;
 - d) the processor is configured to determine, according to the second matrix, a second code associated with the second wireless entity; and
 - e) the processor is further configured to determine, according to the blockchain, a second wireless address associated with the second code.
- 18.** The system of claim **17**, wherein:
- a) the first code comprises a first wireless address of the first wireless entity; and
 - b) the second code comprises a second wireless address, a frequency, and a bandwidth.
- 19.** The system of claim **18**, wherein the processor is further configured to determine, according to the blockchain, the second wireless address, the frequency, and the bandwidth associated with the second code.
- 20.** The system of claim **19**, wherein the processor is further configured to transmit a message to the second wireless entity, the second message transmitted according to the second wireless address, the frequency, and the bandwidth.

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