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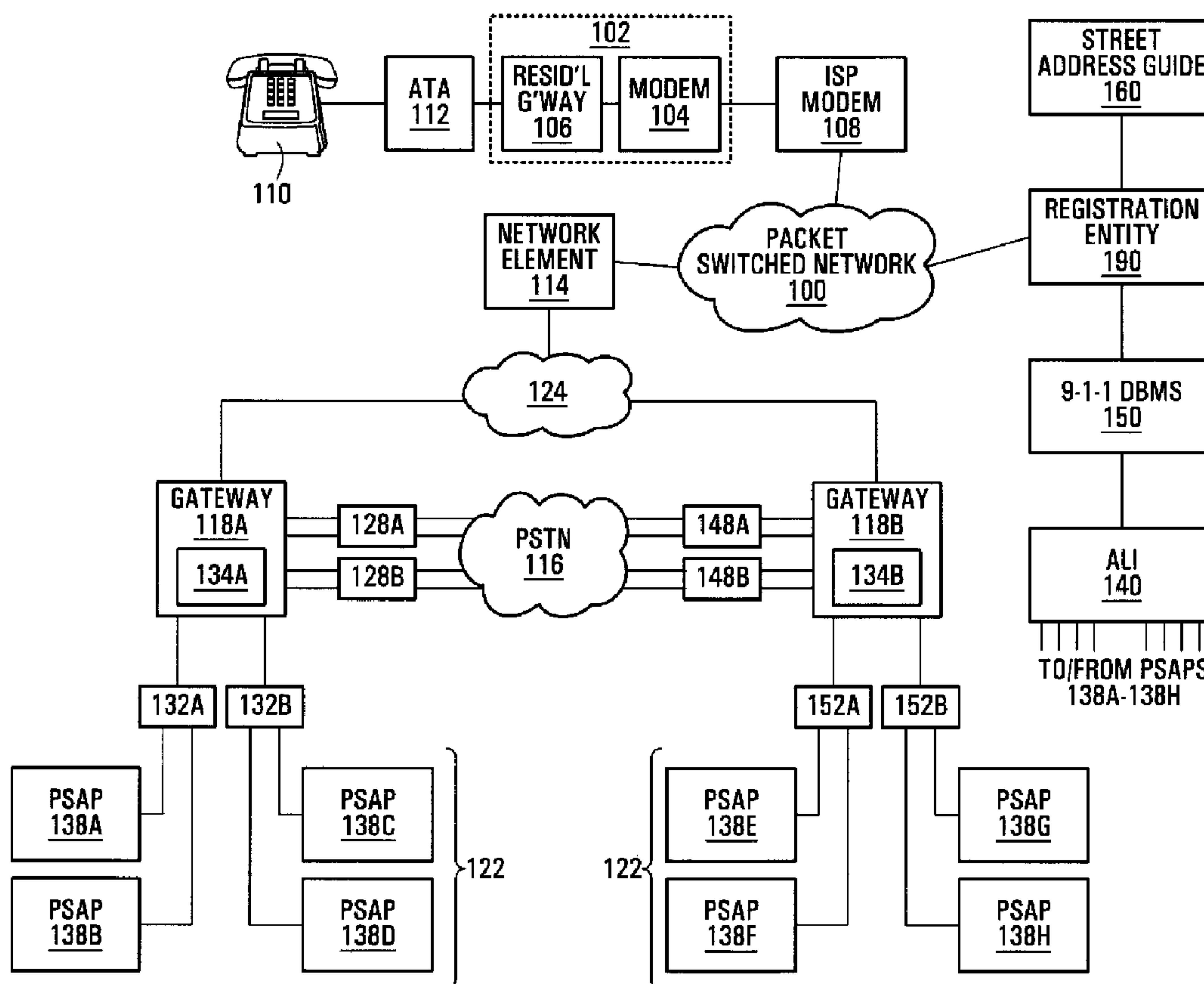
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(54) Title: EMERGENCY CALL HANDLING IN A VOICE-OVER-PACKET ENVIRONMENT



(57) Abrégé/Abstract:

A method of routing an emergency call received at a network element. The method comprises determining a directory number associated with a communication device having originated the emergency call, consulting a local database to obtain routing

(57) Abrégé(suite)/Abstract(continued):

information associated with the directory number, and directing the call and the routing information over a path dedicated to emergency calls. Also, a network element which comprises the database as well as a control entity, the control entity being operative for receiving an incoming call originated by one of the communication devices, determining the directory number associated with the communication device having originated the call, determining whether the call is an emergency call and, responsive to the call being an emergency call, accessing the database to obtain the routing information related to the directory number and directing the call as well as the routing information over a trunk group dedicated to emergency calls.

1 Abstract

2

3 A method of routing an emergency call received at a network element. The method
4 comprises determining a directory number associated with a communication device
5 having originated the emergency call, consulting a local database to obtain routing
6 information associated with the directory number, and directing the call and the
7 routing information over a path dedicated to emergency calls. Also, a network
8 element which comprises the database as well as a control entity, the control entity
9 being operative for receiving an incoming call originated by one of the
10 communication devices, determining the directory number associated with the
11 communication device having originated the call, determining whether the call is an
12 emergency call and, responsive to the call being an emergency call, accessing the
13 database to obtain the routing information related to the directory number and
14 directing the call as well as the routing information over a trunk group dedicated to
15 emergency calls.

16

1 EMERGENCY CALL HANDLING IN A
2 VOICE-OVER-PACKET ENVIRONMENT
3
4

5 Field of the Invention
6

7 The present invention relates to the field of telecommunications in general and, more
8 specifically, to the delivery of emergency services to users of communication devices
9 in a network that provides voice-over-packet services.
10

11 Background
12

13 The current Emergency Services Enhanced 9-1-1 (E911) infrastructure in North
14 America is based on a distribution of Primary Public Safety Answering Points (P-
15 PSAPs, hereinafter referred to solely as PSAPs) accessible from the Public Switched
16 Telephone Network (PSTN) via a special group of telephone lines dedicated solely to
17 emergency use. The same applies to other emergency codes used in other parts of the
18 world, e.g., E112 in continental Europe, E999 in England, etc.
19

20 In the current infrastructure, each individual telephone number is assigned a
21 corresponding PSAP that is nearest to the physical location of the user of that
22 telephone number. The physical location of the user is assessed on the basis of the
23 area code and local exchange of the telephone number. When a user places an
24 emergency call, the calling party's telephone number is transmitted with the call, and
25 on the basis of the originating telephone number, the emergency call will be routed to
26 the designated PSAP along one of the dedicated emergency lines. Upon receipt at the
27 PSAP, the call is answered by a trained responder. By virtue of an automatic location
28 identification (ALI) database which maps each telephone number to an address, the
29 responder is able to obtain the physical location of the calling party and dispatch a
30 police officer, firefighter or ambulance as necessary.
31

32 With the advent of the Internet, society has witnessed the expansion of a global
33 packet-switched network into an ever increasing number of homes and businesses.
34 This has put ever increasing numbers of users into contact with one another, usually at

1 little cost for unlimited use. Meanwhile, advances have been made in delivering voice
2 communication over packet networks, driven primarily by the cost advantage of
3 placing long-distance calls over the Internet as opposed to the leased lines of the
4 world's telcos. Technology dealing with the delivery of real-time voice calls over a
5 packet-switched network is generally known as voice-over-packet or voice-over-
6 Internet-Protocol (voice-over-IP), and often simply referred to as "VoIP".

7
8 From a purely technological standpoint, the successful deployment of VoIP has
9 several challenges, typically related to latency and congestion. Still, despite these and
10 other technical drawbacks, many consumers have opted to subscribe to VoIP services,
11 motivated by significant cost savings in the area of long-distance calling. This has led
12 to a trend, whereby some residential and business consumers have actually chosen to
13 abandon their "basic" PSTN connection in favour of a VoIP connection, not only to
14 satisfy their long distance requirements but also to conduct local, day-to-day
15 telephony. One area where this shift to all-VoIP paradigm can be problematic for
16 consumers (and VoIP service providers) is in the delivery of emergency services.

17
18 Specifically, the call delivery technology is fundamentally different for VoIP, and as a
19 result, the dialing of 9-1-1 during a VoIP connection does not work today in the same
20 way as for a basic PSTN connection. For example, VoIP users can select their own
21 telephone numbers, which may comprise an "area code" and a "local exchange" that
22 are unrelated to the physical location from which calls will be placed. If the VoIP
23 user dials 9-1-1, the call may be directed to a PSAP located in a different part of the
24 country, significantly reducing the value of the emergency services being provided.

25
26 Recognizing these defects, some VoIP service providers have enhanced their offerings
27 in the area of emergency services. For example, there are consumer VoIP solutions
28 which allow the transfer of a 9-1-1 call from the VoIP network to the nearest PSAP in
29 accordance with level i1 of the service levels proposed by the National Emergency
30 Number Association (NENA) and the Voice over the Net (VON) coalition.

31
32 However, in accordance with this and other i1-compliant solutions, emergency calls
33 are not delivered via the dedicated emergency lines and trunks described above, but
34 instead arrive at the nearest PSAP via the PSAP's ordinary, i.e., administrative, lines.

1 Since many PSAPs are unprepared to handle calls over ordinary telephone lines, this
2 creates a variety of problems, ranging from the low priority typically given to
3 administrative calls, to the possibility of having an emergency call answered by
4 improperly trained staff such as a receptionist or, worse still, by an auto-attendant
5 during off-normal hours.

6
7 Against this background, it is clear that further improvements are needed in the
8 delivery of emergency services to persons dialing 9-1-1 from a VoIP-enabled
9 telephone or device.

10
11 Summary of the Invention

12
13 A first broad aspect of the present invention seeks to provide a method of routing an
14 emergency call received at a network element. The method comprises determining a
15 directory number associated with a communication device having originated the
16 emergency call, consulting a local database to obtain routing information associated
17 with the directory number and directing the call and the routing information over a
18 path dedicated to emergency calls.

19
20 According to another broad aspect, the present invention seeks to provide a network
21 element for use in a network that provides voice-over-packet services to a plurality of
22 communication devices, each of the communication devices being associated with a
23 respective directory number. The network element comprises a database that relates
24 routing keys to respective directory numbers and a control entity operative for
25 receiving an incoming call originated by one of the communication devices,
26 determining the directory number associated with the communication device having
27 originated the call, determining whether the call is an emergency call and, responsive
28 to the call being an emergency call, (i) accessing the database to obtain the routing
29 key related to the directory number; and (ii) directing the call and the routing key
30 obtained at (i) over a trunk group dedicated to emergency calls.

31
32 According to yet another broad aspect, the present invention seeks to provide a
33 network architecture for providing voice-over-packet services to a plurality of
34 communication devices, each of the communication devices being associated with a

1 respective directory number. The network architecture comprises a packet switch, a
2 gateway connected to the packet switch and connectable to a circuit-switched
3 emergency network and a database that relates individual directory numbers to
4 respective routing keys. The packet switch is operative for receiving an incoming
5 emergency call from one of the communication devices, determining the directory
6 number associated with the communication device having placed the emergency call,
7 accessing the database to obtain the routing key related to the directory number
8 determined in the previous step, and directing the emergency call, the associated
9 directory number and the associated routing key towards the gateway.

10
11 These and other aspects and features of the present invention will now become
12 apparent to those of ordinary skill in the art upon review of the following description
13 of specific embodiments of the invention in conjunction with the accompanying
14 drawings.

15 16 Brief Description of the Drawings

17
18 In the accompanying drawings:

19
20 Figs. 1A to 1C show in schematic form, various embodiments of an architecture of
21 network elements suitable for the delivery of emergency services;

22
23 Figs. 2A to 2J show interaction of the various network elements in the architecture of
24 Fig. 1A during a provisioning phase;

25
26 Figs. 3A and 3B conceptually illustrate the contents of a table maintained by a
27 network element forming part of the architecture of Fig. 1, in accordance with two
28 specific embodiments of the present invention;

29
30 Figs. 4A to 4F show interaction of the various network elements in the architecture of
31 Fig. 1A during a call handling phase.

32 33 Detailed Description of the Embodiments

1 With reference to Fig. 1A, there is shown a network element architecture suitable for
2 the delivery of emergency services in accordance with an embodiment of the present
3 invention. A packet-switched network 100, which may or may not be the public
4 Internet, comprises a backbone to which users have access via customer premises
5 equipment 102 such as a modem 104 in combination with a residential gateway 106.
6 In some embodiments, the modem 104 and the residential gateway 106 may be
7 combined into a single unit at the customer premises.

8
9 A VoIP customer desirous of obtaining telephony services via the packet-switched
10 network 100 may be provided with a special-purpose VoIP telephone or device that
11 connects directly to the residential gateway 106. In another embodiment, and as
12 illustrated in Fig. 1A, the VoIP customer utilizes a conventional analog telephone 110
13 which connects to the residential gateway 106 using an analog terminal adapter
14 (ATA) 112. The ATA 112 permits the VoIP customer to re-use conventional
15 telephony hardware in a VoIP environment, thus obviating the need to purchase and
16 maintain a second telephone strictly for IP telephony purposes. Generally speaking,
17 however, it is immaterial to the present invention whether the VoIP customer uses a
18 special-purpose VoIP telephone or a conventional analog telephone 110 coupled to an
19 ATA 112.

20
21 In a typical residential application, the packet-switched network 100 is accessed by
22 the modem 104 in the customer premises equipment 102 upon establishing a
23 connection to a modem 108 belonging to a network service provider, commonly an
24 Internet service provider (ISP). The connection is made via an access infrastructure,
25 examples of which include but are not limited to copper telephone lines (for an ADSL
26 modem) 104 and coax cable (for a cable modem 104). It should be further understood
27 that the present invention applies to the delivery of emergency services not only in a
28 residential context but in other contexts such as business and corporate applications,
29 where access to the packet-switched network 100 may be provided by a server that in
30 some cases is directly connected to the packet-switched network 100.

31
32 A VoIP service provider maintains a registration entity 190, which VoIP customers
33 may access via the packet network 100. In a non-limiting example of implementation,
34 the registration entity 190 may be embodied as a server having a control entity and an

1 I/O. Initially, potential VoIP customers contact the VoIP service provider via the
2 registration entity 190. A given VoIP customer registers with the registration entity
3 190 and obtains a VoIP telephone number N (hereinafter referred to as a “directory
4 number”). The VoIP customer, identified by the directory number N , can then begin
5 to place calls into (and receive calls from) the packet-switched network 100. The
6 registration entity 190 performs various other functions which will be described in
7 further detail later on.

8
9 At the edge of the packet-switched network 100 there is provided a network element
10 114, which may be referred to as a packet switch or softswitch, and which comprises
11 suitable circuitry, software and/or control logic for providing various communication
12 services to VoIP customers. Examples of such communication services include but
13 are not limited to call waiting, call forwarding, and so on. In addition, the network
14 element 114 comprises suitable circuitry, software and/or control logic for exchanging
15 calls with entities outside the packet-switched network 100. Where a call is placed by
16 a VoIP customer, there are at least two circumstances that require the call to pass
17 through the network element 114, namely, (i) a call placed to a telephone number that
18 is reachable only via the Public Switched Telephone Network (PSTN) 116 and (ii) an
19 emergency call.

20
21 In the former case, the network element 114 detects when a VoIP customer in the
22 packet-switched network 100 is attempting to reach a destination that can only be
23 reached via the PSTN 116, in which case the call is routed via a network 124 to one of
24 a plurality of gateways 118A, 118B that connect to the PSTN 116.

25
26 In the latter case, the network element 114 detects when a VoIP customer in the
27 packet-switched network 100 has dialed (either explicitly or via a speed dial function
28 or in some other way) an emergency number such as “9-1-1”. In such a case, the call,
29 hereinafter referred to as an emergency call, is routed to one of the gateways 118A,
30 118B, which connect not only to the PSTN 116 as described above, but also to a
31 network of dedicated emergency lines and Public Safety Answering Points (PSAPs),
32 hereinafter collectively referred to as an E911 network 122.

33

1 In addition to the above, when handling an emergency call, the network element 114
2 comprises circuitry, software and/or control logic suitable for outputting a “routing
3 key” associated with the directory number of the VoIP customer having placed the
4 emergency call. The routing key accompanies the emergency call as it is routed by
5 the network element 114 to the appropriate one of the gateways 118A, 118B. Further
6 detail regarding routing keys and the operation of the network element 114 will be
7 given later on in this description.

8
9 In a specific example of implementation, the network element 114 is the Multimedia
10 Communication Server 5200 from Nortel Networks Limited, Brampton, Ontario,
11 Canada, although it should be understood that the present invention applies equally to
12 other makes, models and types of packet switches or softswitches that have (or can be
13 configured to have) the ability to assign a routing key to a VoIP customer’s directory
14 number.

15
16 As previously mentioned, the network element 114 is connected to the gateways
17 118A, 118B via the network 124. In some embodiments, the network 124 may be
18 part of the packet-switched network 100 while in other embodiments it may not. In
19 still other embodiments, rather than being connected via the network 124, the network
20 element 114 may be connected to each gateway 118A, 118B by a respective
21 communication link that can be optical fiber, coaxial cable, wireless, free-space
22 optical, etc. It is noted that the network 124 (or the communication link(s), as the case
23 may be) carries multiple telephone calls simultaneously. In an embodiment of the
24 present invention, emergency calls are treated differently from non-emergency calls
25 and therefore it is envisaged that distinct virtual trunk groups will be established for
26 either type of call (non-emergency and emergency), as well as for each of the
27 gateways 118A, 118B.

28
29 In addition to communicating with the network element 114 via the network 124, the
30 gateways 118A, 118B in Fig. 1A also communicate with components of the PSTN
31 116 and the E911 network 122. Specifically, gateway 118A is connected to the PSTN
32 116 via a plurality of high-capacity switches 128A, 128B and is also connected to the
33 E911 network 122 via a plurality of high-capacity switches 132A, 132B. Similarly,
34 gateway 118B is connected to the PSTN 116 via a plurality of high-capacity switches

1 148A, 148B and is also connected to the E911 network 122 via a plurality of high-
2 capacity switches 152A, 152B. It should be understood that the specific architecture
3 shown in Fig. 1A is merely for purposes of illustration; in other architectures that are
4 within the scope of the present invention, there may be more or fewer gateways, and
5 not all gateways need be connected to both the PSTN 116 and the E911 network 122.

6
7 In a specific example of implementation, each or either of the gateways 118A, 118B
8 may be embodied as the Communication Server 2000 from Nortel Networks Limited,
9 Brampton, Ontario, Canada, although it should be understood that the present
10 invention applies equally to other makes, models and types of gateways.

11
12 An example of a basic function of the gateways 118A, 118B is to allow non-
13 emergency calls originated in the packet-switched network 100 to be completed via
14 the PSTN 116 (which is circuit-switched) and *vice versa*. Another example of a basic
15 function of the gateways 118A, 118B is to take emergency calls originated in the
16 packet-switched network 100 and to route them into the E911 network 122, which is
17 circuit-switched (much like the PSTN 116).

18
19 Continuing with the description of the architecture in Fig. 1A, switch 132A is
20 connected via a first portion of the E911 network 122 to a first plurality of PSAPs,
21 including PSAP 138A and PSAP 138B, while switch 132B is connected via a second
22 portion of the E911 network 122 to a second plurality of PSAPs, including PSAP
23 138C and PSAP 138D. Similarly, switch 152A is connected via a third portion of the
24 E911 network 122 to a third plurality of PSAPs, including PSAP 138E and PSAP
25 138F, while switch 152B is connected via a fourth portion of the E911 network 122 to
26 a fourth plurality of PSAPs, including PSAP 138G and PSAP 138H. Of course, this
27 distribution of PSAPs is not to be considered as limiting.

28
29 Each switch routes a received call in accordance with a connection map. For an
30 emergency call received at a given one of the switches 132A, 132B, 152A and 152B,
31 the call will specify a desired PSAP to be reached. The identity of the desired PSAP
32 may be expressed in the form of a "E911 telephone number". Thus, for example,
33 switch 132B will recognize an emergency call that has an associated "E911 telephone
34 number" which specifies either PSAP 138C or PSAP 138D, and will route the

1 emergency call accordingly. The E911 telephone number of may correspond to the
2 telephone number of a specific PSAP along a dedicated in the E911 network 122, and
3 is usually held confidential by the local exchange carrier.
4

5 In addition, switches 132A, 132B, 152A and 152B may have a further ability to
6 forward an emergency call towards a specialized entity other than the PSAPs shown
7 in the drawings. The desirability of doing so arises when a trained responder at a
8 PSAP determines that a special agency (e.g., police, fire or ambulance) may need to
9 be contacted. Forwarding of the emergency call may be done in accordance with a
10 forwarding table that maps plural emergency telephone numbers to each directory
11 number. Each emergency telephone number mapped to a given directory number is
12 associated with a respective forwarding code that signifies either "police", "fire" or
13 "ambulance". During an actual call received at a PSAP, a particular forwarding code
14 would be applied by a trained responder at the PSAP in question and sent to switch
15 132B. Upon receipt of the particular forwarding code, switch 132B is operative to
16 look up the directory number of the call in question and to forward the emergency call
17 towards the appropriate agency using the emergency telephone number for the
18 forwarding code in question. In practice, the trained responder may enter into a three-
19 way conference before the call forward is complete.
20

21 It has already been mentioned that PSTN calls and emergency calls are received from
22 the network 124 over different virtual trunk groups. This makes it a simple task for a
23 particular one of the gateways 118A, 118B to determine towards which network (i.e.,
24 the PSTN 116 or the E911 network 122) to direct a given call. However, in the case
25 of an emergency call received by, say, gateway 118A, there is still a question of
26 whether to route the call towards switch 132A or towards switch 132B. To this end,
27 gateway 118A maintains a connection map 134A which associates each potential
28 received routing key with one of the switches, either switch 132A or switch 132B. In
29 addition, gateway 118A may convert the routing key into a format more
30 understandable to the switches 132A, 132B. One example of a more understandable
31 format is the "E911 telephone number" format mentioned above. The E911 telephone
32 number accompanies the emergency call as it is routed by the gateway 118A to the
33 appropriate one of the switches 132A, 132B.
34

1 In an analogous fashion, gateway 118B maintains a connection map 134B and also
2 may convert received routing keys into E911 telephone numbers. Further detail
3 regarding E911 telephone numbers and the operation of the gateways 118A, 118B
4 will be given later on in this description.

5
6 Switches 132A, 132B, 152A and 152B currently operate entirely within the circuit-
7 switched domain. However, this does not rule out the possibility of the switches
8 132A, 132B, 152A and 152B being retrofitted with the functionality of an IP gateway
9 that would allow an IP connection from the network element 114 directly to the
10 switches 132A, 132B, 152A and 152B via dedicated virtual trunk groups, thus
11 bypassing the need for gateways 118A and 118B in this intermediate position. This
12 possibility is envisaged in Fig. 1C. It is noted that a set of gateways 198A, 198B is
13 still used to connect the network element 114 to the legacy switches 128A, 128B,
14 148A, 148B leading to the PSTN 116.

15
16 Returning to Fig. 1A, the PSAPs 138A to 138H are connected to an ALI database
17 140. The ALI database 140 is a known database that stores street addresses and
18 associated telephone numbers, thus enabling a PSAP operator to obtain the street
19 address corresponding to a given directory number from which an emergency call has
20 originated. The ALI database 140 is connected to a 9-1-1 database management
21 system (9-1-1 DBMS) 150, which maintains a mapping of street addresses to
22 "emergency zones", such as a municipality, county or district, for example. The 9-1-1
23 DBMS 150 is accessible to the registration entity 190, either by a direct link or via the
24 packet-switched network 100.

25
26 The architecture in Fig. 1A also comprises a street address guide (SAG) 160, which is
27 accessed by the registration entity 190, either by a direct link or via the packet-
28 switched network 100. The street address guide 160 provides validation of a street
29 address in order to determine whether a particular entry corresponds to a realistic
30 address.

31
32 In accordance with an embodiment of the present invention, certain steps are
33 performed for each VoIP customer during a provisioning phase, which occurs before
34 the placement of an emergency call by that VoIP customer, and is now described with

1 reference to the signal flow diagrams in Figs. 2A through 2H, which correspond to
2 steps 2-A through 2-H. In fact, it may be advantageous to perform the following steps
3 during the same general time frame as when the VoIP customer obtains his or her
4 directory number *N*.

5
6 At step 2-A, the VoIP customer provides a service address to the registration entity
7 190. The service address, which may differ from the billing address, is typically the
8 geographic location of the VoIP customer, which may be the civic (street) address
9 where the VoIP customer is located, although it is envisaged that in some
10 embodiments it may be the latitude / longitude of the VoIP customer or some other
11 form of localization data. The manner in which the VoIP customer provides the
12 service address to the registration entity 190 is not material to the present invention
13 and may include the usage of the web, email, snail mail, etc. It is noted that step 2-A
14 may be performed at the same time as when the VoIP customer is first assigned a
15 directory number *N* and in fact it is envisaged that the execution of step 2-A may even
16 be made a condition for the delivery of VoIP services.

17
18 At step 2-B, the registration entity 190 validates the service address supplied by the
19 user. This can be achieved by running the service address through a street address
20 guide (SAG) 160 that is available to the VoIP service provider. Validation provides
21 an assurance that the service address given by the user is a valid address, i.e., really
22 exists, and therefore will be capable of being meaningfully associated with an
23 emergency zone and its designated PSAP. If validation at step 2-B is unsuccessful,
24 then the VoIP customer may be asked to re-enter the service address with a greater
25 degree of precision or may be prompted to resolve an ambiguity by choosing the
26 service address from a list of two or more address choices. Step 2-B may also be
27 performed interactively with the VoIP customer and may involve the intervention of a
28 customer service representative.

29
30 Provided validation at step 2-B is successful, the registration entity 190 proceeds to
31 step 2-C, which consists of supplying the validated street address to the 9-1-1 DBMS
32 150. The 9-1-1 DBMS 150 has the functionality of identifying an emergency zone
33 associated with the service address. In one embodiment, the 9-1-1 DBMS 150
34 maintains a mapping that associates postal codes (zip codes) to emergency zones.

1 Thus, a given service address having a given postal code will map to a corresponding
2 emergency zone.

3
4 At step 2-D, the 9-1-1 DBMS 150 returns a file processing confirmation 209 to the
5 registration entity 190. The file processing confirmation 209 may identify the
6 emergency zone (hereinafter denoted 210) associated with the service address in
7 question.

8
9 At step 2-E, which may actually be executed before step 2-D, the 9-1-1 DBMS 150
10 provides the directory number *N* and the validated street address to the ALI database
11 140 for storage therein.

12
13 At step 2-F, the 9-1-1 DBMS 150 updates the forwarding tables at the switches 132A,
14 132B, 152A, 152B, with routing information 202 for the purposes of eventual call
15 transfer to dispatch agencies (police, fire, ambulance) as per established routines. In
16 an example, the individual emergency telephone numbers corresponding to police,
17 fire and ambulance agencies which are associated with emergency zone 210 are
18 entered into the forwarding table in association with directory number *N*.

19
20 At step 2-G, which may actually be executed before step 2-F, the registration entity
21 190 consults a call routing list (CRL) 188, which associates emergency zones 210 to
22 individual "routing keys" 214. The result of step 2-G is the obtaining of a routing key
23 214 that corresponds to the emergency zone 210. By virtue of the association
24 between each directory number *N* and its emergency zone 210, and by virtue of the
25 association between each emergency zone 210 and its routing key 214, it will be
26 apparent that each directory number *N* will be associated with a routing key 214.
27 Also, since more than one emergency zone may be serviced by the same PSAP, a
28 plurality of directory numbers *N* will share the same routing key 214.

29
30 At step 2-H, the registration entity 190 provides the directory number *N* and the
31 associated routing key 214 (obtained at step 2-G) to the network entity 114. The
32 network entity 114 enters this information into a table 178 local to the network entity
33 114. The table 178 may be stored in the network entity 114 or otherwise directly
34 accessible thereto.

1

2 Fig. 3A shows a specific, non-limiting example of the table 178 that is local to the
3 network entity 114. Basically, the table 178 comprises a plurality of records 204,
4 each containing a directory number *N* and a related routing key 214. A particular
5 routing key 214 comprises information that defines a route to be taken by an
6 emergency call in order to reach a particular PSAP. In one embodiment, not to be
7 considered as limiting, the routing key 214 comprises a gateway identifier 214A and a
8 routing code 214B. Further detail regarding the purpose and effect of fields 214A,
9 214B will be given later on in this specification.

10

11 In an alternative embodiment of steps 2-G and 2-H, shown in Figs. 2-I and 2-J, the
12 registration entity 190 provides the directory number *N* and the associated emergency
13 zone 210 to the network entity 114, and it is the network entity 114 that consults a call
14 routing list (CRL) 188 in order to obtain the appropriate routing key 214 for the
15 emergency zone 210 in question. In this case, and with reference to Fig. 3B, the table
16 178' local to the network element 114 would comprise a plurality of records, each
17 containing a directory number *N*, a related emergency zone 210 and a related routing
18 key 214.

19

20 With additional reference now to the diagrams of Figs. 4-A to 4-F, placement of an
21 emergency call and operation of the various elements in the architecture of Fig. 1 in a
22 "call handling" phase is now described.

23

24 At step 4-A, the network element 114 detects an emergency call 400 received from a
25 VoIP customer associated with a particular directory number *N*.

26

27 At step 4-B, the network element 114 consults the table 178 (or 178') which is local to
28 the network element 114 and retrieves the routing key 214 for the directory number *N*.
29 As previously mentioned, the routing key 214 contains a gateway identifier 214A,
30 which identifies the destination gateway towards which the emergency call 400
31 should be routed. Let this destination gateway be gateway 118A. In addition, the
32 routing key 214 contains a routing code 214B which, when interpreted by gateway
33 118A, will identify (i) a destination switch towards which gateway 118A should route
34 the emergency call 400 and (ii) the destination PSAP for the emergency call 400. For

1 the purposes of this example, let the destination switch be switch 132B and let the
2 destination PSAP be PSAP 138C.

3

4 At step 4-C, the network element 114 routes the emergency call 400 onto the virtual
5 trunk group assigned to the destination gateway, in this case gateway 118A. In
6 addition, as part of step 4-C, the network element 114 forwards the routing code 213B
7 along with the emergency call 400. In an alternative embodiment, the network
8 element 114 forwards the routing key 214 in its entirety. The forwarded information
9 accompanies the emergency call 400 as it is routed to gateway 118A.

10

11 At step 4-D, the gateway 118A receives the emergency call 400 from the network
12 element 114. The emergency call 400 is accompanied by at least the routing code
13 214B. Gateway 118A reads the routing code 214B in order to learn (i) the identity of
14 the destination switch (in this case switch 132B) towards which the emergency call
15 400 should be routed by gateway 118A and (ii) the identity of the destination PSAP
16 (in this case PSAP 132C) towards which the emergency call 400 should be routed by
17 the destination switch 132B. Additionally, gateway 118A obtains the E911 telephone
18 number corresponding to the destination PSAP 138C, hereinafter denoted 250. The
19 destination gateway 118A then proceeds to route the emergency call 400 to the
20 destination switch 132B and forwards the E911 telephone number 250 along with the
21 emergency call 400.

22

23 At step 4-E, the destination switch (in this case switch 132B) routes the received
24 emergency call 400. Routing is performed on the basis of the E911 telephone number
25 250 received from gateway 118A, resulting in the emergency call 400 being
26 transferred onto a dedicated line leading towards the destination PSAP (in this case
27 PSAP 138C) over the E911 network 122.

28

29 At step 4-F, once the incoming emergency call 400 is received at the destination
30 PSAP 138C, it is handled by a trained responder. With knowledge of the directory
31 number *N* (which follows the emergency call 400 from its inception), the responder
32 obtains the validated service address associated with the directory number *N*. In one
33 embodiment, the responder queries the ALI database 140 upon receipt of the
34 emergency call 400 in order to obtain the validated service address. In an alternative

1 embodiment, the validated service address is pushed by the ALI database 140 during a
2 previous step. Specifically, after step 4-E described above, receipt of the emergency
3 call 400 by switch 132B could be followed by switch 132B supplying the directory
4 number N to the ALI database 140, which then pushes the validated service address to
5 the destination PSAP 138C. In either case, the responder learns the exact geographic
6 location of the caller and can dispatch emergency personnel if necessary.

7

8 In an example scenario, the responder may determine that a particular type of
9 emergency agency (police, ambulance, fire) needs to be dispatched. A forwarding
10 code can be dialed back to switch 132B from which the emergency call 400
11 originated. The forwarding code triggers switch 132B to use its internal forwarding
12 table in order to forward the emergency call 400 to a particular emergency telephone
13 number where the appropriate agency can be reached. Since the updating of the
14 forwarding table was done in the provisioning phase at step 2-F (as described earlier),
15 the emergency call 400 will be automatically forwarded to the agency of the
16 appropriate type that is geographically in the best position to handle the emergency
17 call 400.

18

19 Of course other embodiments of explicit routing using a routing key 214 are within
20 the scope of the present invention. For instance, it is envisaged that the routing code
21 214B mentioned above may comprise only the E911 telephone number 250
22 corresponding to the destination PSAP. In such a scenario, a gateway that receives
23 the emergency call and the associated E911 telephone number 250 would access a
24 local table to obtain the identity of the switch that is connected to the destination
25 PSAP. In fact, the functionality of consulting a local table could be relegated to
26 network element 114, such that it is the network element 114 that determines the ports
27 that need to be used by the gateway when routing the emergency call in question, in
28 order that the call reach the destination PSAP. Fig. 1B shows such an embodiment,
29 where the connection maps (134A, 134B in Fig. 1A, formerly executed by the
30 gateways 118A, 118B, respectively) have been consolidated into a single connection
31 map executed at the network element 114.

32

33 From the above description, it will be noted that the assignment of a routing key 214
34 to each directory number N permits independence of the directory number N and the

1 destination PSAP. In other words, there need not be any relationship between the
2 “area code” or “local exchange” of the directory number *N* and the destination PSAP,
3 which is unlike the case with the traditional telephony infrastructure. As a result,
4 VoIP service providers can assign arbitrary directory numbers to their customers,
5 while ensuring that emergency services will be dispatched effectively by the
6 appropriate PSAP for each customer. Moreover, as has been shown using the
7 example of Figs. 4-A to 4-F, emergency calls 400 can be directed to the appropriate
8 PSAP over a dedicated emergency circuit in the E911 network 122, rather than over
9 an administrative line, thereby maximally assuring a prompt response by trained
10 personnel.

11

12 Those skilled in the art will appreciate that in some embodiments, the functionality of
13 parts of the network element 114 and/or the registration entity 190 may be
14 implemented as pre-programmed hardware or firmware elements (e.g., application
15 specific integrated circuits (ASICs), electrically erasable programmable read-only
16 memories (EEPROMs), etc.), or other related components. In other embodiments,
17 parts of the network element 114 and/or the registration entity 190 may be
18 implemented as an arithmetic and logic unit (ALU) having access to a code memory
19 (not shown) which stores program instructions for the operation of the ALU. The
20 program instructions could be stored on a medium which is fixed, tangible and
21 readable directly by the network element 114 and/or the registration entity 190, (e.g.,
22 removable diskette, CD-ROM, ROM, or fixed disk), or the program instructions could
23 be stored remotely but transmittable to the network element 114 and/or the
24 registration entity 190 via a modem or other interface device (e.g., a communications
25 adapter) connected to a network over a transmission medium. The transmission
26 medium may be either a tangible medium (e.g., optical or analog communications
27 lines) or a medium implemented using wireless techniques (e.g., microwave, infrared
28 or other transmission schemes).

29

30 While specific embodiments of the present invention have been described and
31 illustrated, it will be apparent to those skilled in the art that numerous modifications
32 and variations can be made without departing from the scope of the invention as
33 defined in the appended claims.

1 What is claimed is:

2

3 1. A method of routing an emergency call received at a network element,
4 comprising:

- 5 ➤ determining a directory number associated with a communication device
6 having originated the emergency call;
7 ➤ consulting a local database to obtain routing information associated with the
8 directory number; and
9 ➤ directing the call and the routing information over a path dedicated to
10 emergency calls.

11

12 2. The method defined in claim 1, wherein the path dedicated to emergency calls
13 includes a virtual trunk group.

14

15 3. The method defined in claim 1, wherein the path dedicated to emergency calls
16 comprises dedicated circuit-switched lines.

17

18 4. The method defined in claim 2, wherein the path dedicated to emergency calls
19 further comprises dedicated circuit-switched lines.

20

21 5. A network element for use in a network that provides voice-over-packet services
22 to a plurality of communication devices, each of the communication devices being
23 associated with a respective directory number, the network element comprising:

- 24 ➤ a database that relates routing keys to respective directory numbers;
25 ➤ a control entity operative for:
26 ➤ receiving an incoming call originated by one of the communication
27 devices;
28 ➤ determining the directory number associated with the communication
29 device having originated the call;
30 ➤ determining whether the call is an emergency call;
31 ➤ responsive to the call being an emergency call:
32 (i) accessing the database to obtain the routing key related to the directory
33 number; and

- 1 (ii) directing the call and the routing key obtained at (i) over a trunk group
2 dedicated to emergency calls.
3
- 4 6. The network element defined in claim 5, wherein the trunk group dedicated to
5 emergency calls is a virtual trunk group.
6
- 7 7. The network element defined in claim 5, wherein the control entity being
8 operative to determine whether the call is an emergency call comprises the control
9 entity being operative to determine whether a set of leading digits have been
10 dialed.
11
- 12 8. The network element defined in claim 5, wherein the control entity being
13 operative to determine whether the call is an emergency call comprises the control
14 entity being operative to determine whether the set of leading digits is selected
15 from the group consisting of "9-1-1 ", "1-1-2" and "9-9-9".
16
- 17 9. The network element of claim 5 being a packet switch.
18
- 19 10. The network element of claim 5 being a softswitch.
20
- 21 11. The network element of claim 5 being a multimedia communication server
22 (MCS).
23
- 24 12. The network element defined in claim 5, wherein the network element is
25 connected to a plurality of public safety answering points (PSAPs) via a dedicated
26 emergency network, wherein the routing key related to a particular directory
27 number associated with a particular communication device defines a route to a
28 particular one of the PSAPs.
29
- 30 13. A network architecture for providing voice-over-packet services to a plurality of
31 communication devices, each of the communication devices being associated with
32 a respective directory number, the network architecture comprising:
33 (a) a packet switch;

- 1 (b) a gateway connected to the packet switch and connectable to a circuit-
2 switched emergency network;
- 3 (c) a database that relates individual directory numbers to respective routing keys;
- 4 (d) wherein the packet switch is operative for:
- 5 ➤ receiving an incoming emergency call from one of the communication
6 devices;
- 7 ➤ determining the directory number associated with the communication
8 device having placed the emergency call;
- 9 ➤ accessing the database to obtain the routing key related to the directory
10 number determined in the previous step;
- 11 ➤ directing the emergency call, the associated directory number and the
12 associated routing key towards the gateway.
- 13
- 14 14. The network architecture defined in claim 13, wherein directing the emergency
15 call towards the gateway is performed over a trunk group dedicated to emergency
16 calls.
- 17
- 18 15. The network architecture defined in claim 14, wherein the trunk group dedicated
19 to emergency calls is a virtual trunk group.
- 20
- 21 16. The network architecture defined in claim 15, the gateway being operative for:
- 22 ➤ receiving the incoming emergency call, the associated directory number and
23 the associated routing key from the packet switch;
- 24 ➤ determining an emergency telephone number in the circuit-switched
25 emergency network on the basis of the received routing key;
- 26 ➤ directing the emergency call and the associated directory number towards the
27 emergency telephone number determined in the previous step.
- 28
- 29 17. A network architecture for providing voice-over-packet services to a plurality of
30 communication devices, each of the communication devices being associated with
31 a respective directory number, the network architecture comprising:
- 32 (a) a packet switch;
- 33 (b) a gateway connected to the packet switch and connectable to a circuit-
34 switched emergency network;

- 1 (c) a database that relates individual directory numbers to respective routing keys;
2 (d) wherein the packet switch is operative for:
3 ➤ receiving an incoming call originated by one of the communication
4 devices;
5 ➤ determining the directory number associated with the communication
6 device having originated the call;
7 ➤ determining whether the call is an emergency call;
8 ➤ responsive to the call being an emergency call:
9 (i) accessing the database to obtain the routing key related to the directory
10 number; and
11 (ii) directing the call and the routing key obtained at (i) towards the gateway.
12

13 18. The network architecture defined in claim 17, wherein directing the emergency
14 call towards the gateway is performed over a trunk group dedicated to emergency
15 calls.
16

17 19. The network architecture defined in claim 18, wherein the trunk group dedicated
18 to emergency calls is a virtual trunk group.
19

20 20. The network architecture defined in claim 19, the gateway being operative for:
21 ➤ receiving the incoming emergency call, the associated directory number and
22 the associated routing key from the packet switch;
23 ➤ determining an emergency telephone number in the circuit-switched
24 emergency network on the basis of the received routing key;
25 ➤ directing the emergency call and the associated directory number towards the
26 emergency telephone number determined in the previous step.
27

28 21. The network architecture defined in claim 20, wherein the packet switch being
29 operative to determine whether the call is an emergency call comprises the packet
30 switch being operative to determine whether a set of leading digits have been
31 dialed.
32

33 22. The network architecture defined in claim 20, wherein the packet switch being
34 operative to determine whether the call is an emergency call comprises the packet

1 switch being operative to determine whether the set of leading digits is selected
2 from the group consisting of “9-1-1”, “1-1-2” and “9-9-9”.
3

4 23. The network element defined in claim 20, wherein the routing key related to a
5 particular directory number associated with a particular communication device
6 defines a route to a particular one of the PSAPs.
7

8 24. A computer-readable storage medium comprising instructions for execution by a
9 computer to implement a method of routing an emergency call received at a
10 network element, the method comprising:

- 11 ➤ determining a directory number associated with a communication device
12 having originated the emergency call;
- 13 ➤ consulting a local database to obtain routing information associated with the
14 directory number; and
- 15 ➤ directing the call and the routing information over a path dedicated to
16 emergency calls.
17

18 25. A computer-readable storage medium comprising computer-readable program
19 code for execution by a computer in a network element upon receipt of an
20 emergency call, the computer-readable program code comprising:

- 21 ➤ computer-readable program code for determining a directory number
22 associated with a communication device having originated an emergency call;
- 23 ➤ computer-readable program code for consulting a local database to obtain
24 routing information associated with the directory number; and
- 25 ➤ computer-readable program code for directing the call and the routing
26 information over a path dedicated to emergency calls.
27

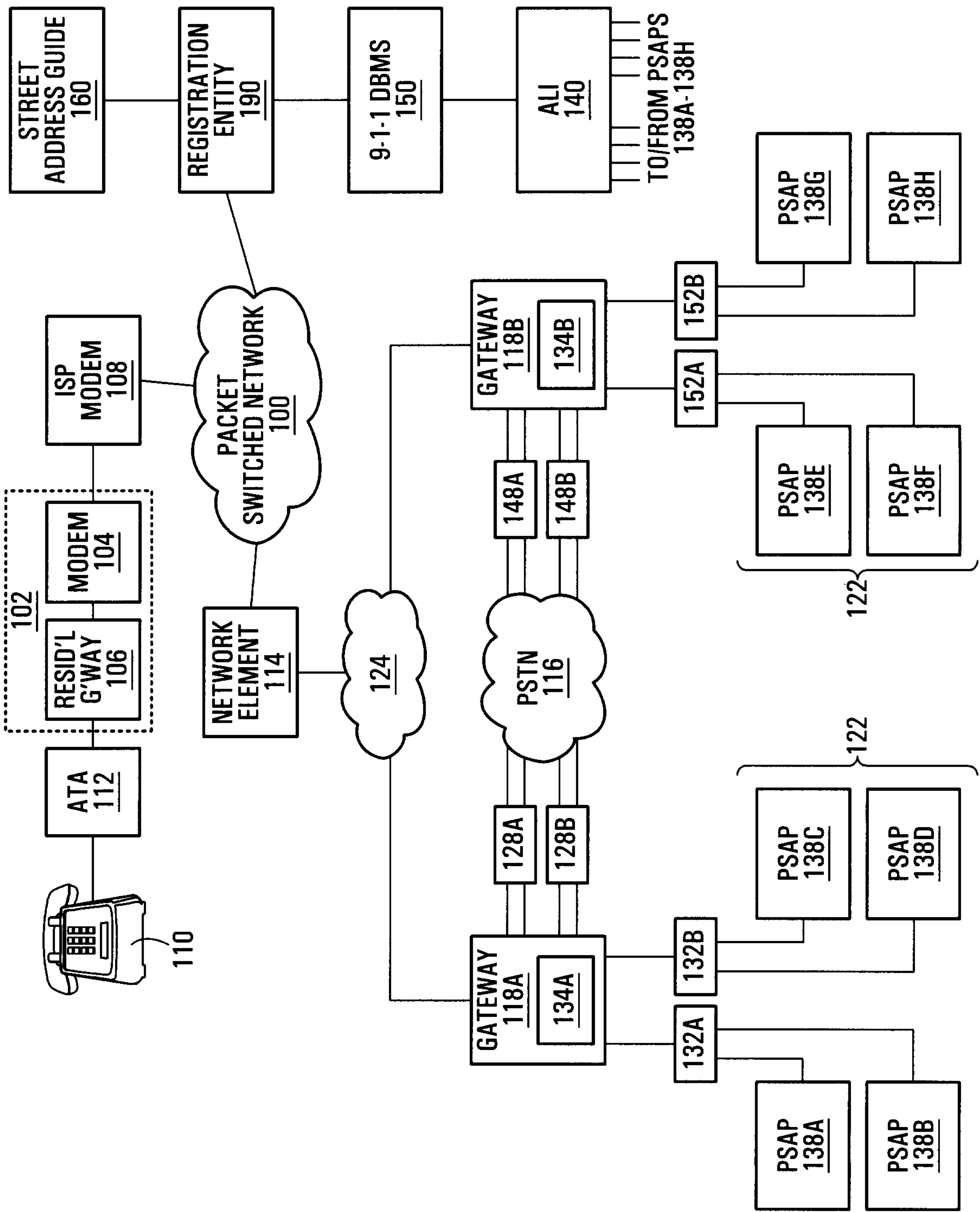


FIG. 1A

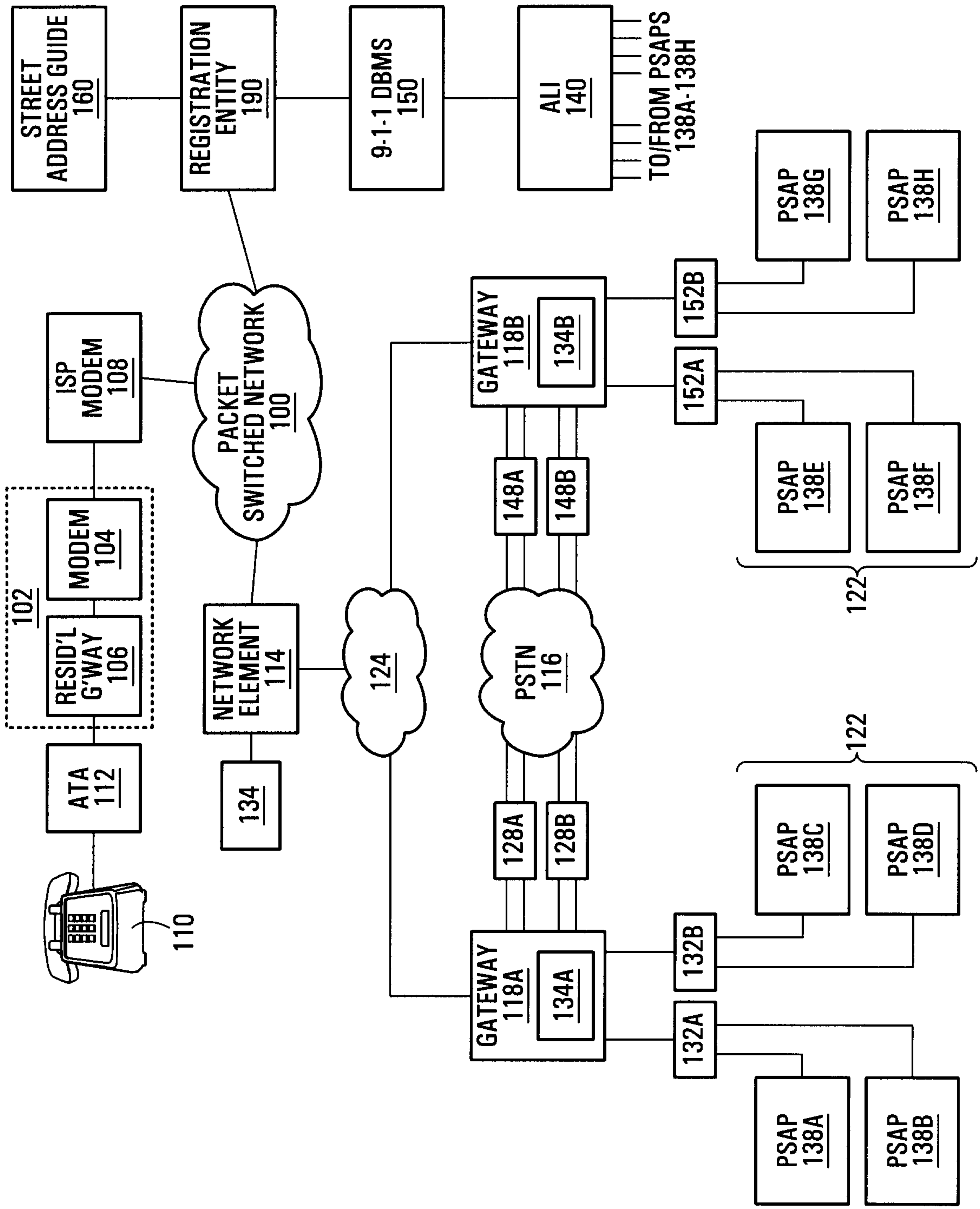


FIG. 1B

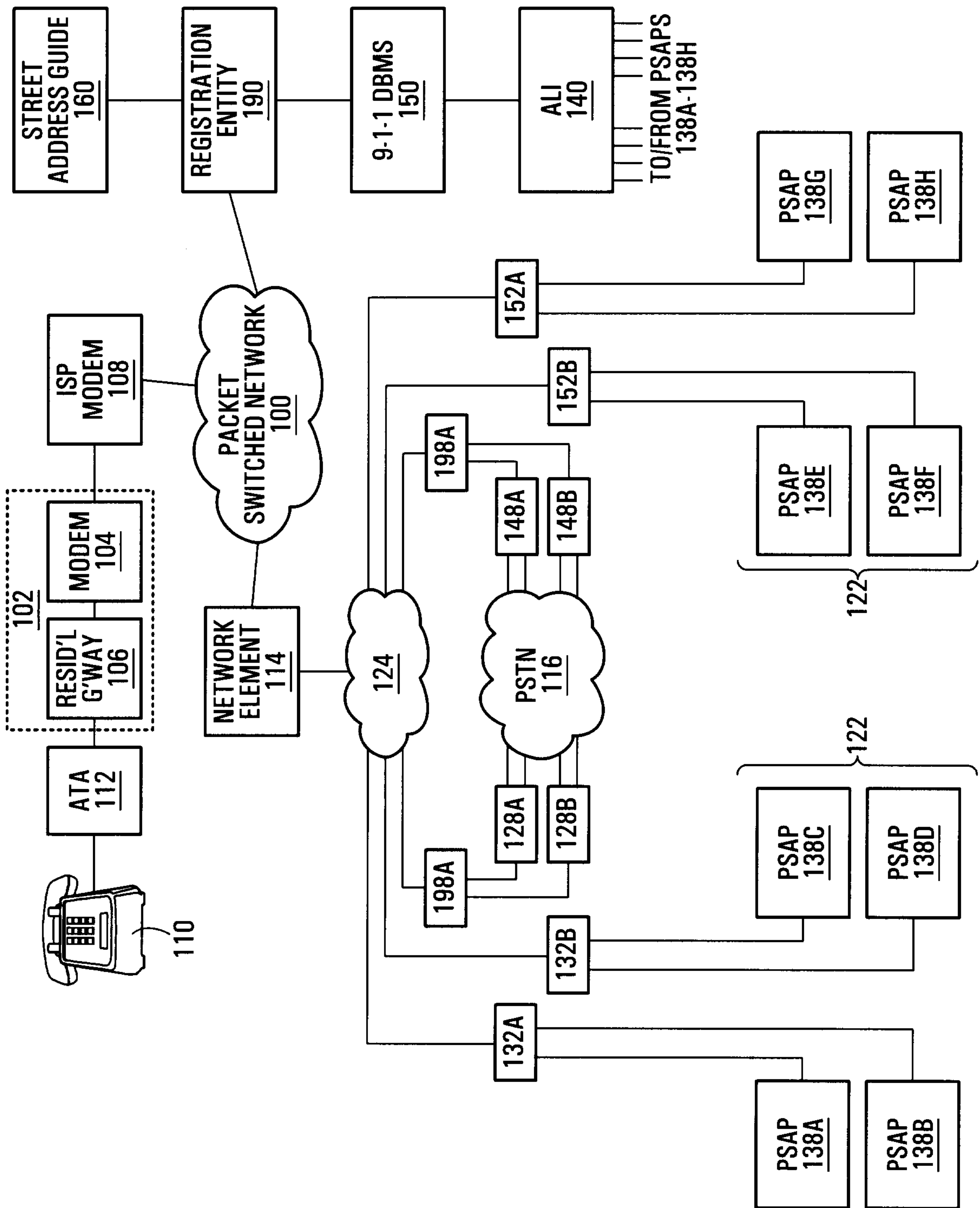


FIG. 1C

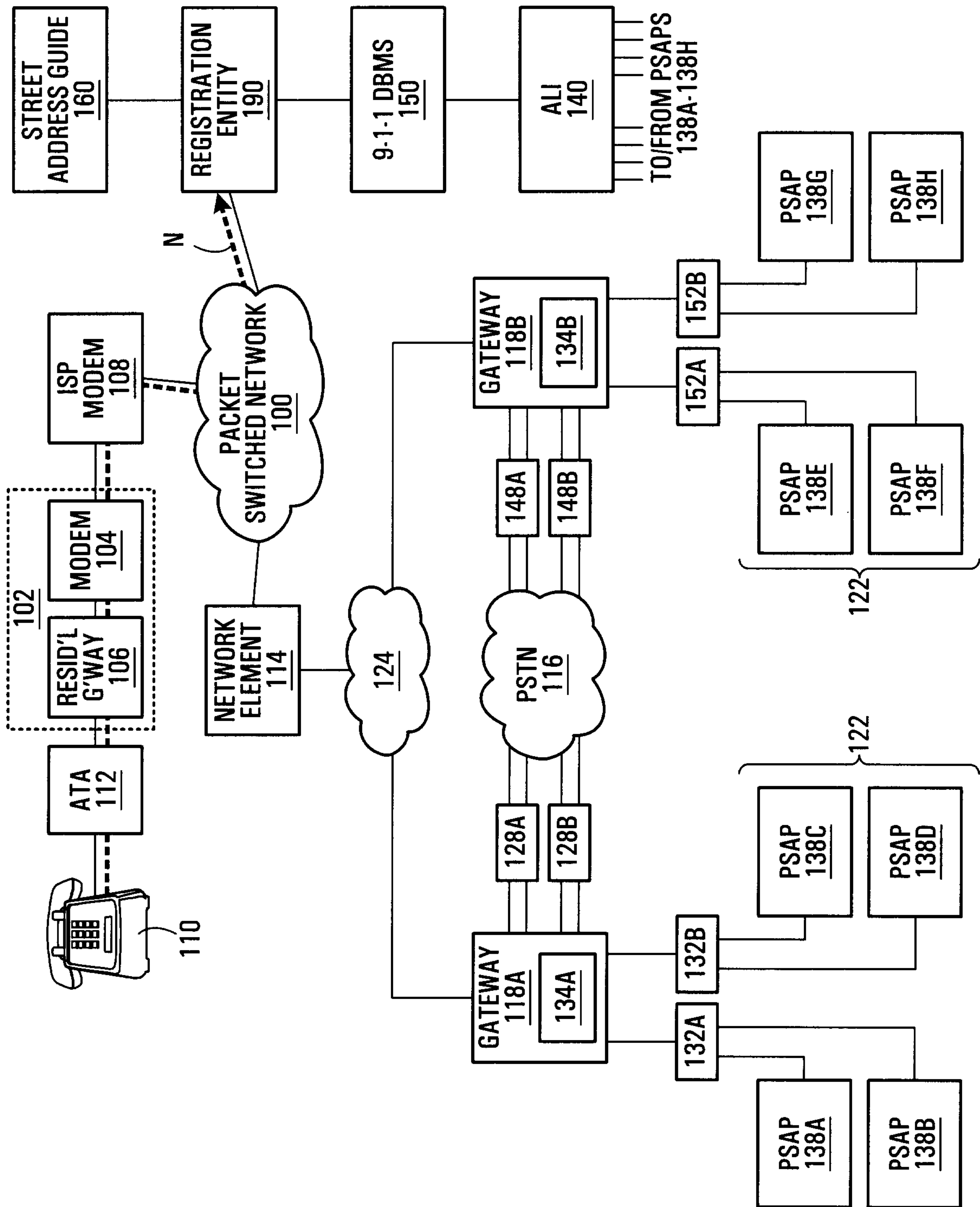


FIG. 2A

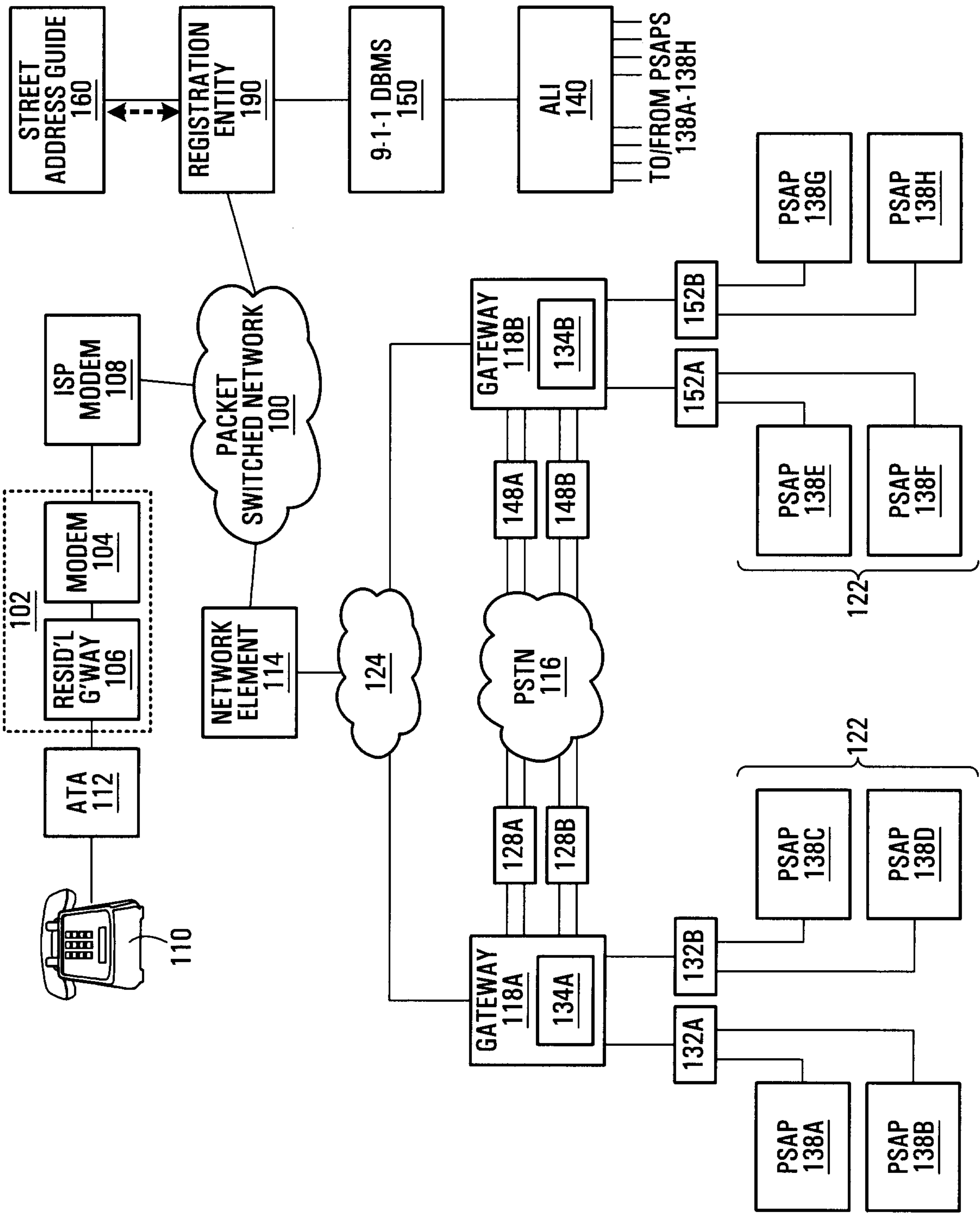


FIG. 2B

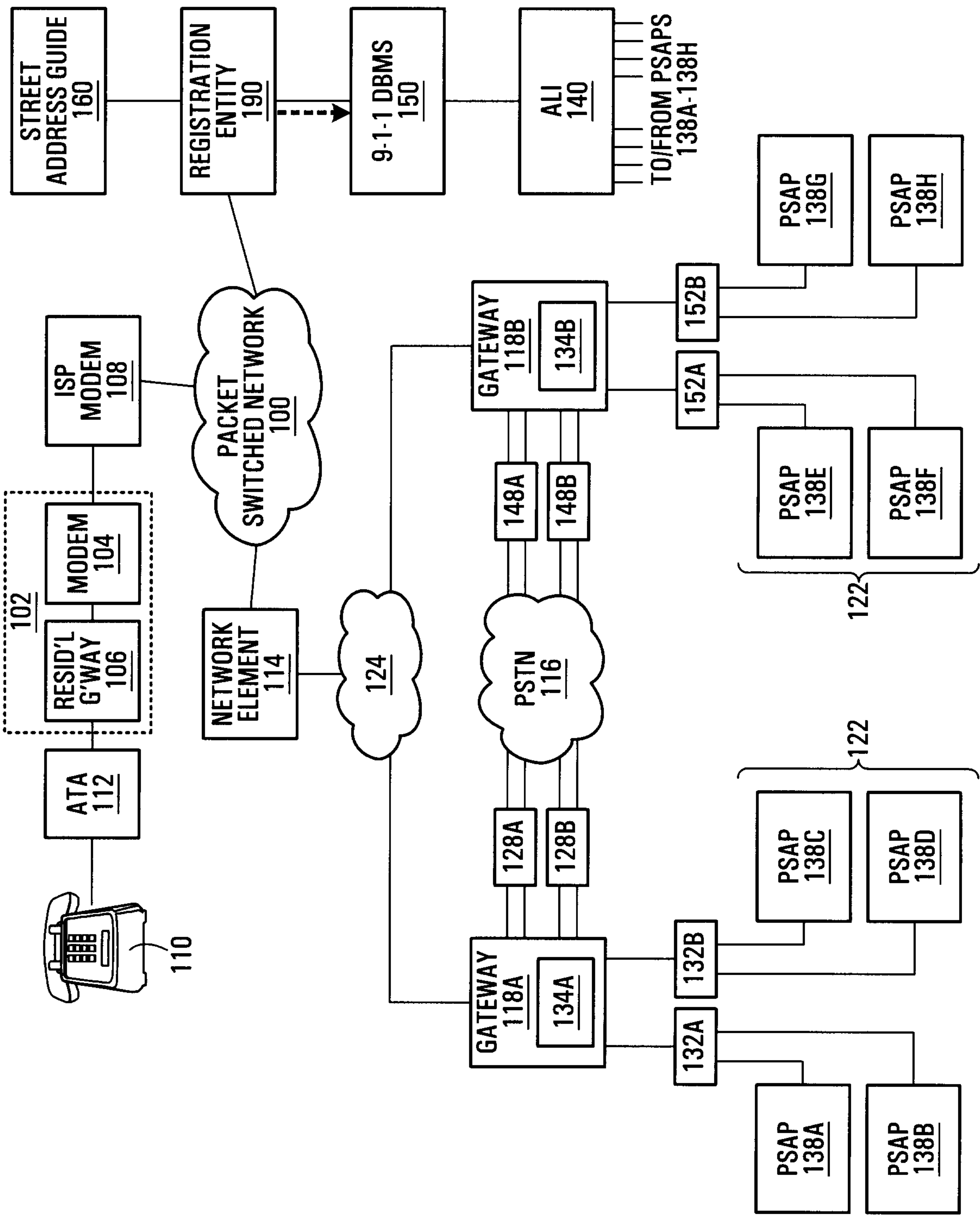


FIG. 2C

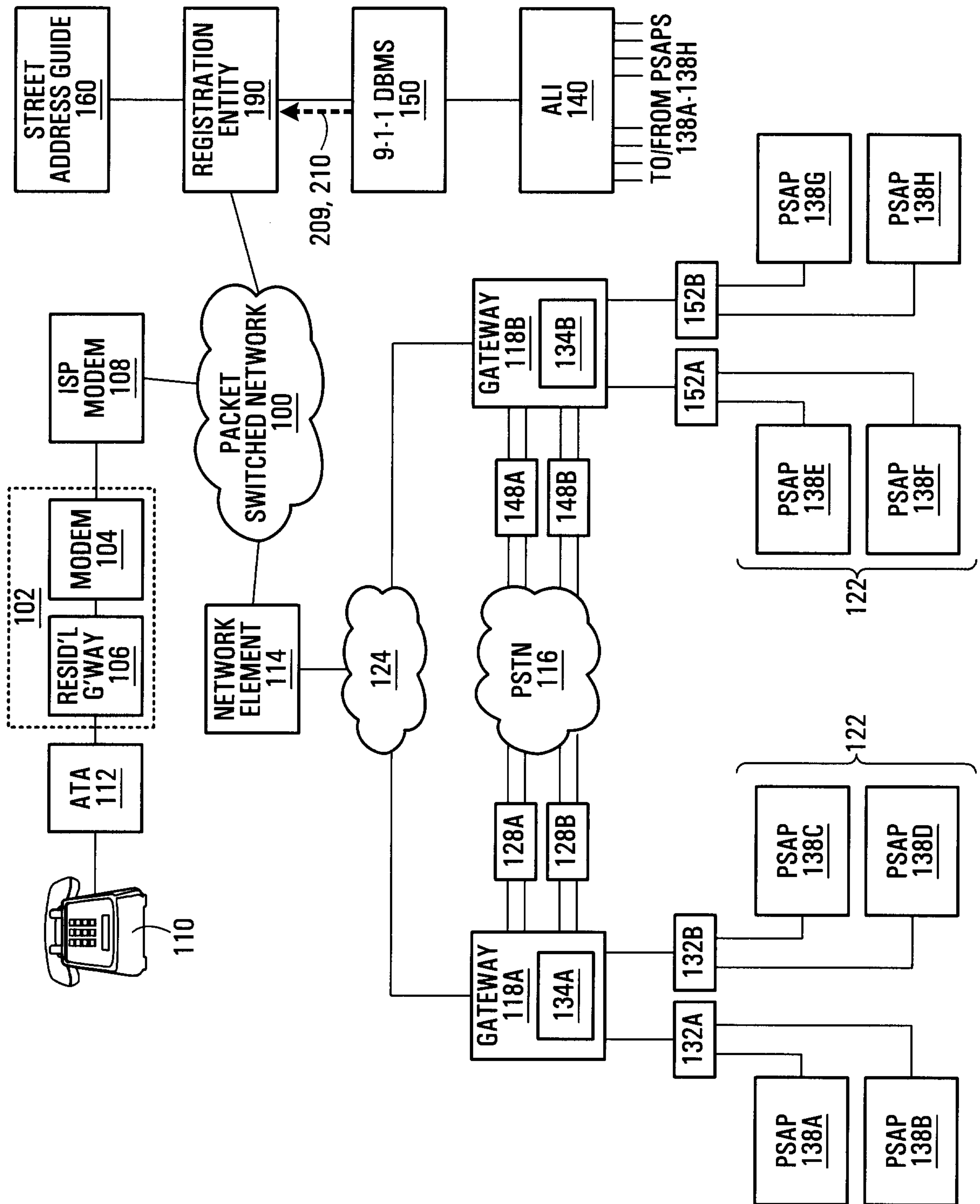


FIG. 2D

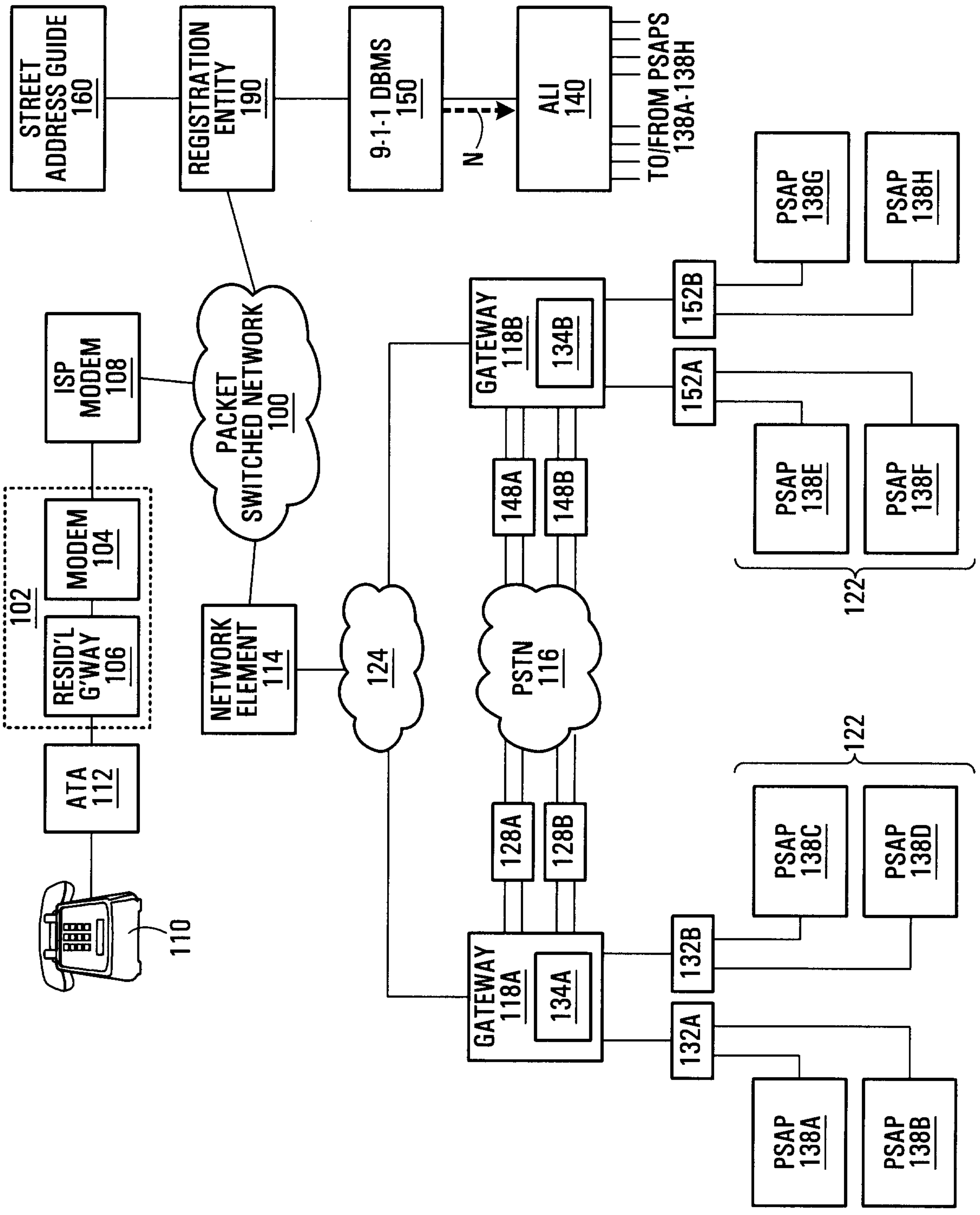


FIG. 2E

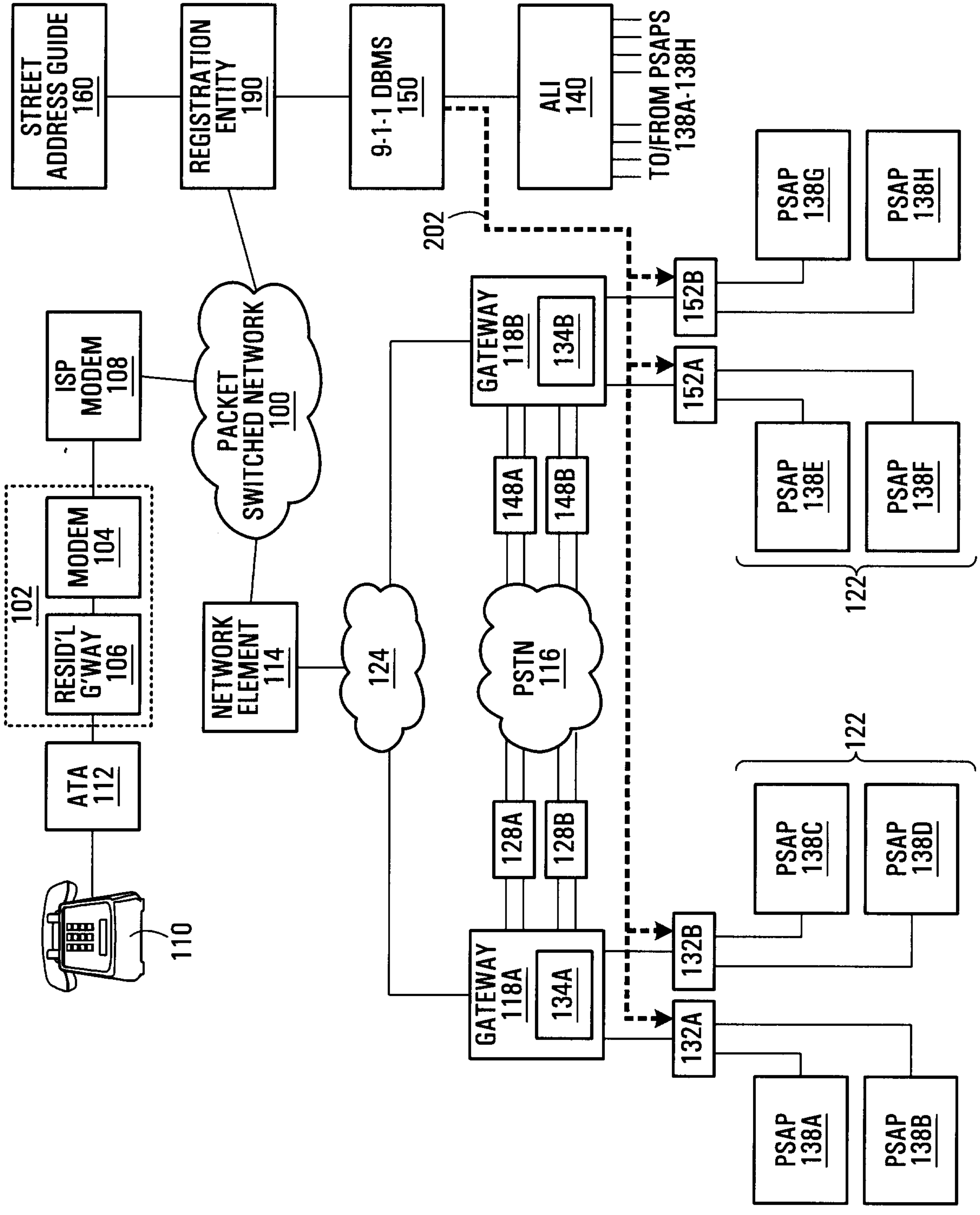


FIG. 2F

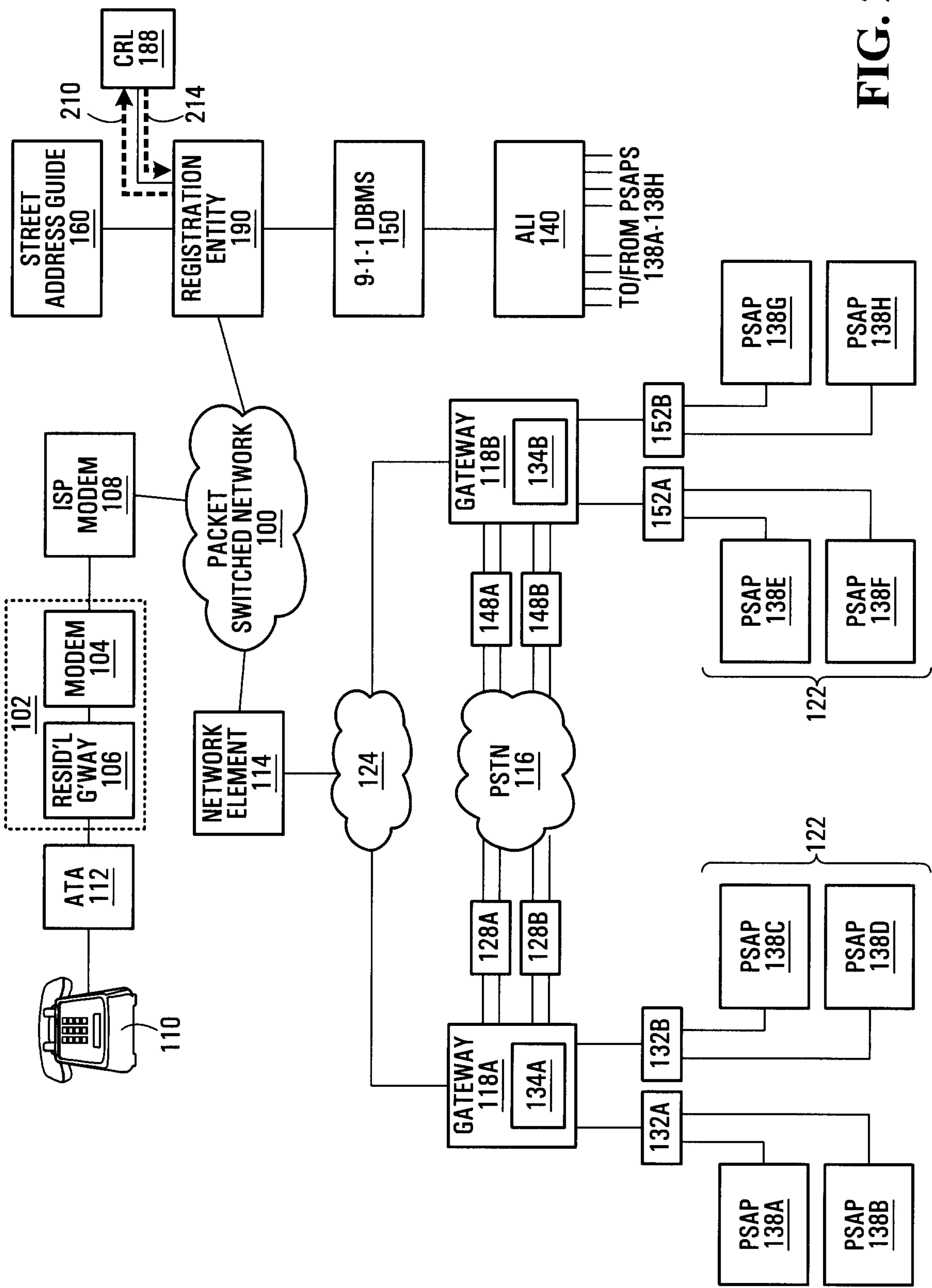


FIG. 2G

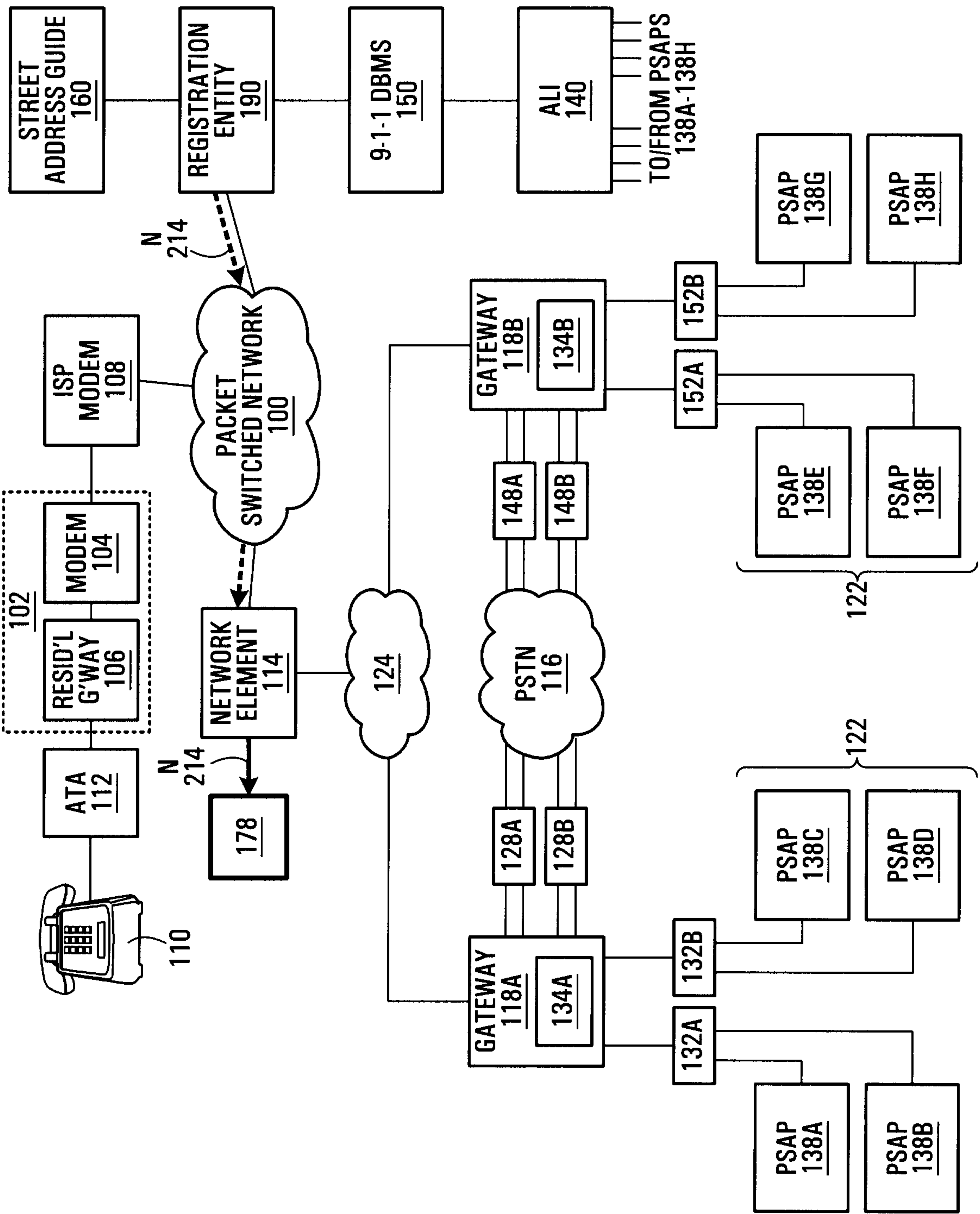


FIG. 2H

12/20

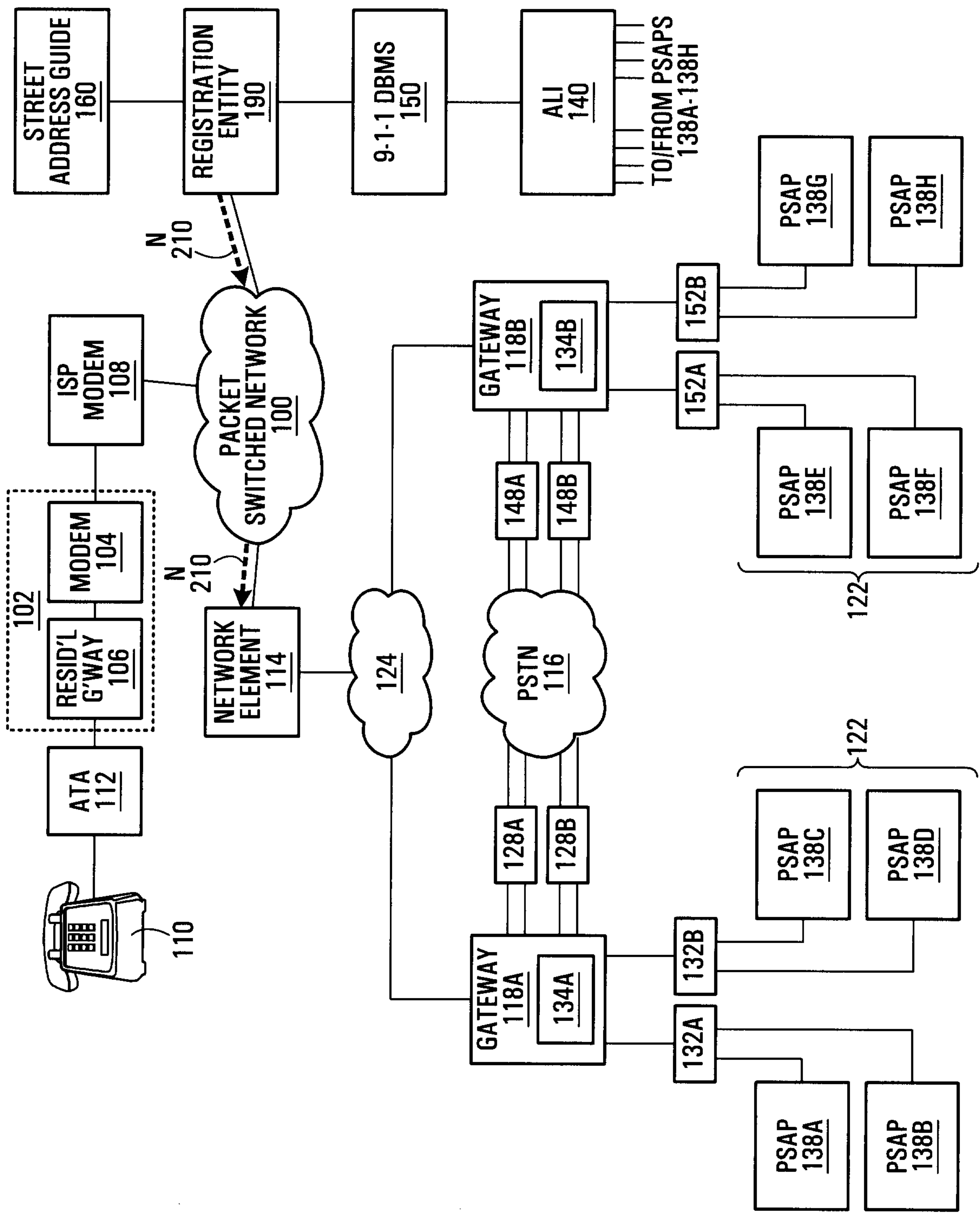


FIG. 2I

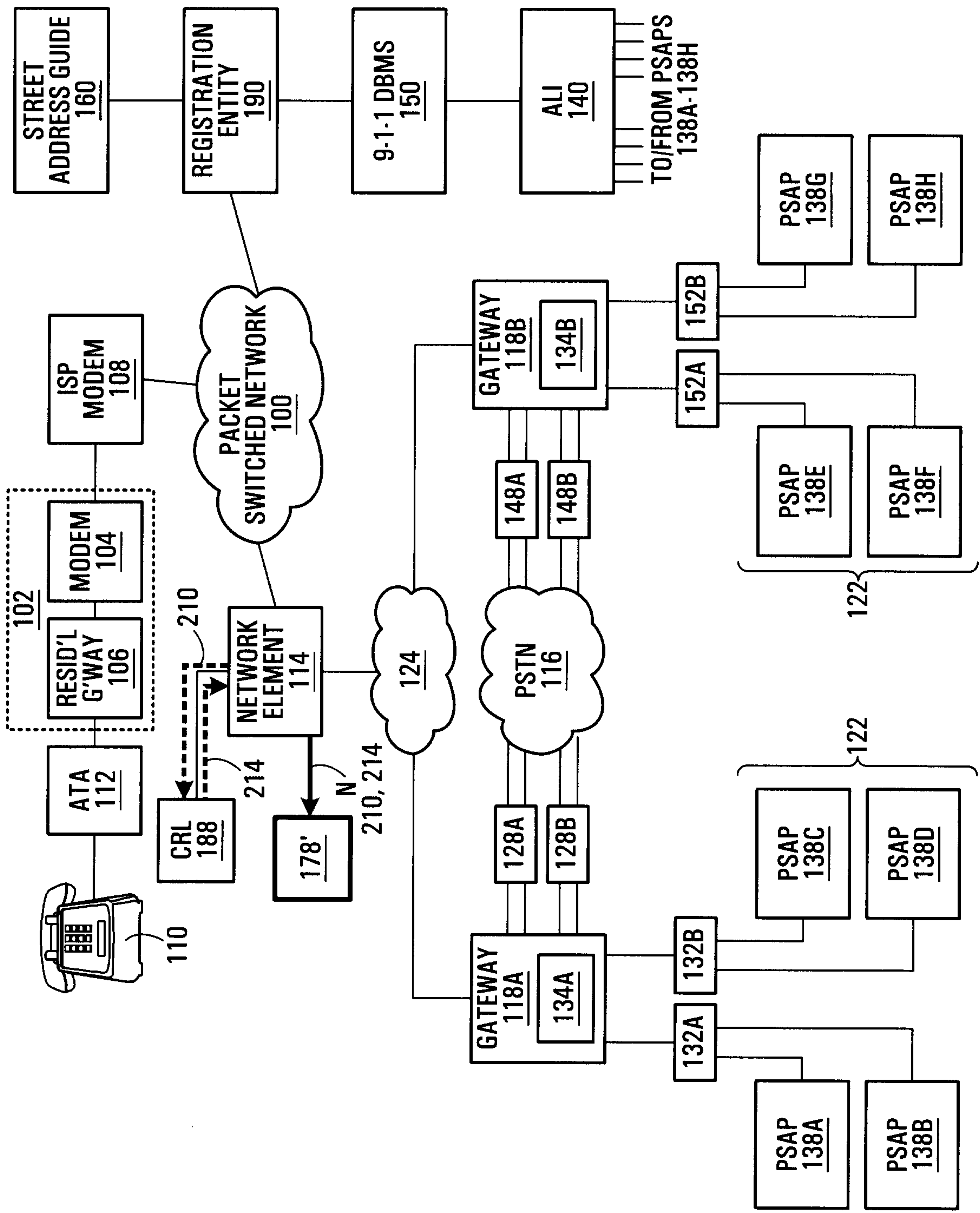


FIG. 2J

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178 {

DIRECTORY NUMBER <i>N</i>	ROUTING KEY <i>214</i>	
	GATEWAY IDENTIFIER <i>214A</i>	ROUTING CODE <i>214B</i>
555-123-4567	XYZ	ABC
555-765-4321	WYZ	CBD

FIG. 3A

178' {

DIRECTORY NUMBER <i>N</i>	EM ZONE <i>210</i>	ROUTING KEY <i>214</i>	
		GATEWAY IDENTIFIER <i>214A</i>	ROUTING CODE <i>214B</i>
555-123-4567	EM1	XYZ	ABC
555-765-4321	EM5	WYZ	CBD

FIG. 3B

+

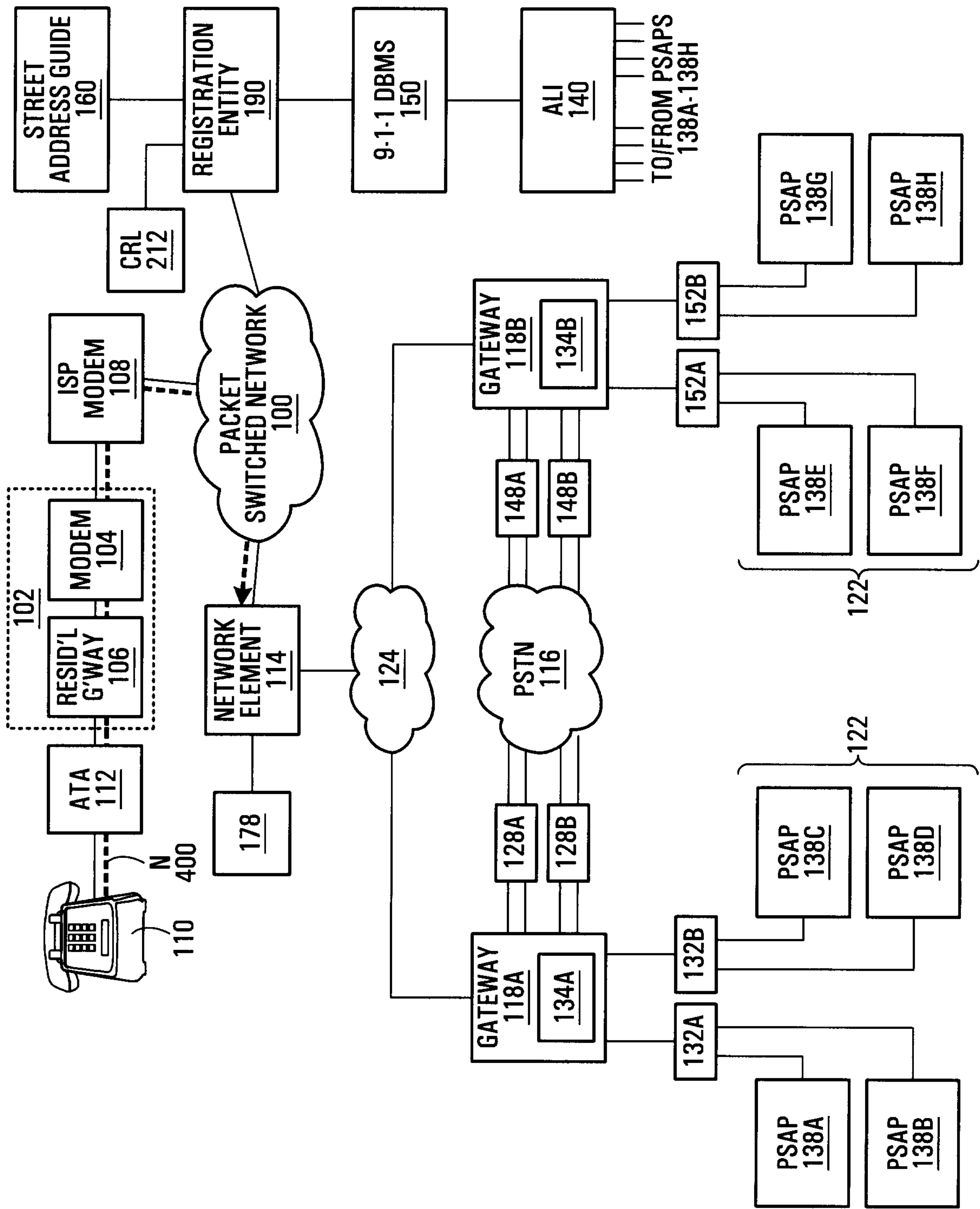


FIG. 4A

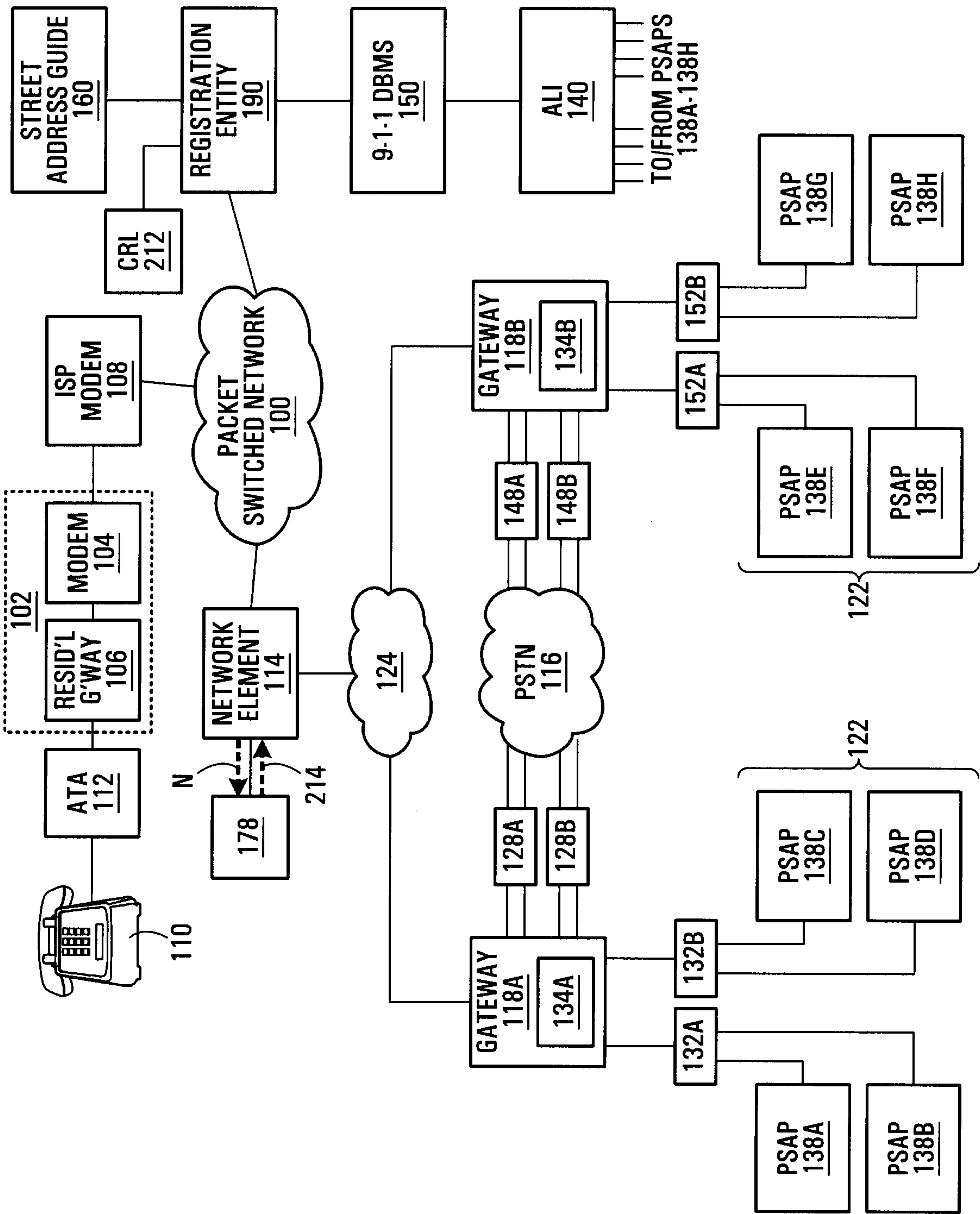


FIG. 4B

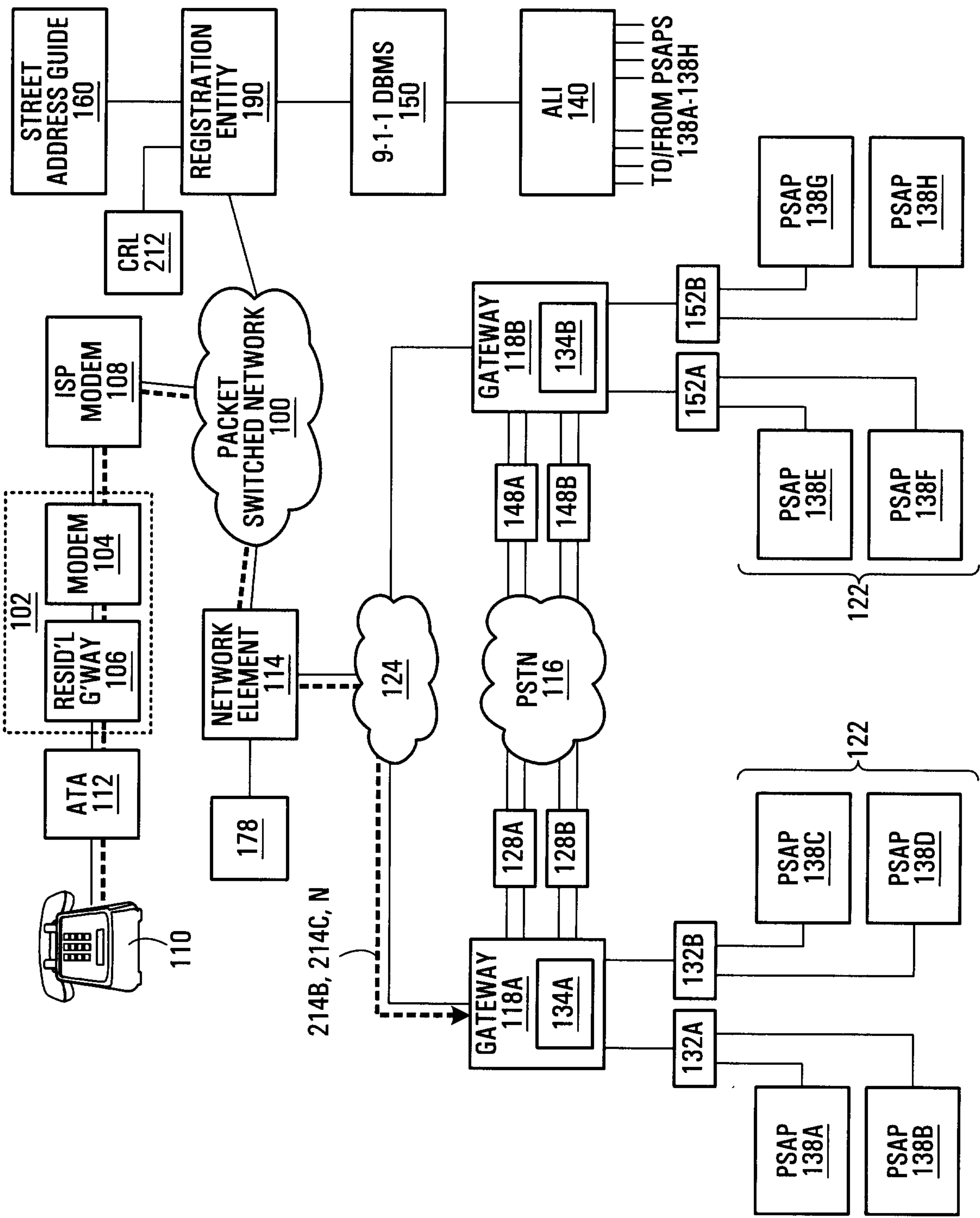


FIG. 4C

