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**Field intensity distribution generator**

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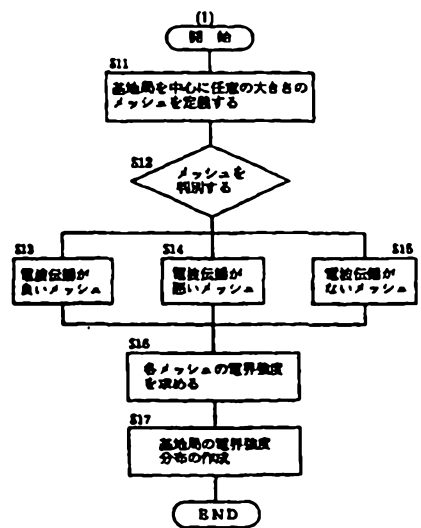
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<p>(21) 国際出願番号 PCT/JP98/00930          (22) 国際出願日 1998年3月6日(06.03.98)          (30) 優先権データ          特願平9/56419 1997年3月11日(11.03.97) JP          (71) 出願人 (米国を除くすべての指定国について)          株式会社 ローカス(LOCUS CORPORATION)[JP/JP]          〒542-0081 大阪府大阪市中央区南船場1丁目16番20号          ムラキビル5階 Osaka, (JP)          (72) 発明者 ; および          (75) 発明者 / 出願人 (米国についてのみ)          神島博昭(KOSHIMA, Hiroaki)[JP/JP]          熊本勝彦(KUMAMOTO, Katsuhiko)[JP/JP]          撫養公雄(MUYA, Kimio)[JP/JP]          〒542-0081 大阪府大阪市中央区南船場1丁目16番20号          ムラキビル7階 株式会社 エースケイコンピューター内          Osaka, (JP)          (74) 代理人          弁理士 深見久郎, 外(FUKAMI, Hisao et al.)          〒530-0054 大阪府大阪市北区南森町2丁目1番29号          住友銀行南森町ビル Osaka, (JP)</p>	<p>(81) 指定国 AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO特許 (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), ユーラシア特許 (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 欧州特許 (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI特許 (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).           添付公開書類          国際調査報告書</p>
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(54) Title: FIELD INTENSITY DISTRIBUTION GENERATOR

(54) 発明の名称 電界強度分布作成装置

(57) Abstract  
 Meshes with arbitrary sizes are defined around a base station by a field intensity distribution generator. Then each mesh is examined whether it is a visible mesh, an invisible mesh, or a mesh which radio waves cannot reach. For the visible meshes, the field intensities are found to generate a field intensity distribution around the base station. As a result, the field intensity distribution generator generates an actual wave propagation pattern around the base station easily.



(1) ... Start  
 S11 ... Meshes with arbitrary sizes are defined around base station.  
 S12 ... Meshes are classified.  
 S13 ... Meshes which radio waves reach well.  
 S14 ... Meshes which radio waves do not reach well.  
 S15 ... Meshes which no radio waves reach.  
 S16 ... Field intensities of respective meshes are found.  
 S17 ... Field intensity distribution around base station is generated.

## Abstract

An electric field intensity distribution preparation apparatus defines the neighborhood about a repeater as a mesh of an arbitrary size. Then, each mesh is determined whether it is a mesh with sight, a mesh without sight, or a mesh that cannot be reached by a wave on the basis of data of an electronic map. The electric field intensity of each mesh is obtained for the mesh with a sight to produce an electric field intensity distribution of the neighborhood of a repeater. As a result, an electric field intensity distribution preparation apparatus that can easily determine a wave propagation pattern centered about a repeater is provided.



Specification  
Electric Field Intensity  
Distribution Preparation Apparatus

5      Technical Field

          The present invention relates to an electric field  
intensity distribution preparation apparatus for obtaining  
the electric field intensity about an electric wave  
generation source and a mobile communication system for  
10      determining the position of a mobile using the electric  
field intensity distribution preparation apparatus. More  
particularly, the present invention relates to a mobile  
communication system that produces an electric field  
intensity distribution using an electronic map to  
15      determine the position of a mobile using the produced  
electric field intensity distribution.

          Background Art

          A mobile position detection method of interest to the  
present invention is disclosed in, for example, Japanese  
20      Patent Publication No. 6-93650. According to the  
publication, waves from a plurality of repeaters are  
respectively received at a mobile in a mobile  
communication system for carrying out communication  
between a repeater and a mobile via the wave. By using a  
25      coverage contour of a reception electric field level from



each repeater obtained in advance, the range in which a mobile can be located corresponding to each reception level is obtained to detect the position of the mobile from the overlap of each range.

5           However, such a position detection method using a coverage contour is a macro detection method that does not take into consideration the blocking and reflection of the waves due to the building around the mobile and the geography in the actual detection of the position of a  
10 mobile. Therefore, this method is suitable for the position detection of a vehicle and the like that travels at high speed. However, there was a problem that this method is not suitable for the position detection of a human being or object that travels at a low speed.

15           Thus, there is a position determining system utilizing a wireless communication network of small zones such as a PHS. In such a positioning system, applications is considered of a radiation pattern of a wave to carry out position detection of high accuracy. Such a small zone  
20 wireless network is shown in Fig. 10.

Referring to Fig. 10, when a fixed or movable center station 91 is to establish conversation communication with a mobile station 7 that is currently on the move, conversation is allowed with a mobile station 7 that is located within a cell 8 of approximately 100m in radius



about a repeater 6 from an exchange station 2 to which center station 91 is connected through a main line 3 and an exchange station 4 through another main line 5. A center control station 51 is connected to main lines 3 and 5.

In a PHS system, there is a PHS database. When center station 91 communicates with mobile station 7, the location of mobile station 7 within cell 8 of repeater 6 is recorded in a database 38 of that repeater provided at center control station 5. Alternatively, the entry of mobile station 7 into the area of cell 8 is immediately stored in the database without effecting communication with repeater 6. It is identified that mobile station 7 is within a circle of a radius of approximately 100m about that repeater 6 by utilizing the position information of repeater 6 that is known in advance. Thus, the location of mobile station 7 can be identified.

The information identifying a repeater 6 corresponding to a certain cell 8 in which mobile station 7 is located at a certain time point can be stored and maintained in the database of the PHS. Technically speaking, center station 91 can receive that information.

Center station 91 includes a system that provides a display of a map information on a display device. It is well known that such a system providing a display of map

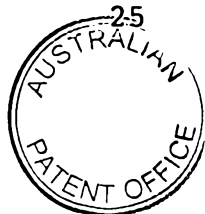


information is easily available in the form of a CD-ROM as in the navigation system of a vehicle.

The position information of a repeater 6 corresponding to a cell 8 in which mobile station 7 is located obtained from the database of the PHS is displayed on a map on the screen of the display device at center station 91. Repeater 6 is indicated by a marker and the like. A circle of 100m in radius is provided on the display centered about the marker. Identification is presented that the mobile station is located within that circle.

Fig. 11 shows a structure of center station 91. Referring to Fig. 11, center station 91 of the present invention includes a personal computer or a work station 12, and a display 61 and a keyboard 11 connected to personal computer or work station 12. Personal computer or work station 12 is connected to a modem 13 for the center station to be connected to a telephone exchange station 2 shown in Fig. 10 via modem 13 for the center station.

In a map 10 appearing on a screen of the display of personal computer or work station 12 at center station 91, a marker 9 indicating a repeater 6 corresponding to a cell 8 in which mobile station 7 is located, and a circle having a radius of 100m (in some cases, may not be a circle) about marker 9 are displayed. It is indicated that



mobile station 7 of interest is located within that circle.  
Mobile station 7 per se cannot be shown on the display.

Fig. 12 is a block diagram showing a specific structure of center station 91. Referring to Fig. 12,  
5 center station 91 includes a CPU 60 for providing the control of the entire apparatus constituting center station 91, a display 61 connected to CPU 60 for providing a display of the location of mobile station 7 on a map, a ROM 62 and a RAM 63 in which a program and the like  
10 defining the operation of center station 91 are stored, and an I/O interface 64 functioning as an interface with an external device.

A CD-ROM drive device 65 for providing a display of map data via I/O interface 64, an automatic calling device  
15 66 for connection to exchange station 2 of the PHS system, and a line disconnection unit 68 for effecting a call by automatic calling device 66 as necessary and disconnecting the line immediately after receiving data of repeater 6 near which mobile station 7 is located are connected. Line  
20 disconnection unit 68 is connected to telephone exchange station 2 via center station modem 13.

In addition to directly designating a mobile station 7 from center station 91 via keyboard 11, the line from a subscriber 71 asking for the position information of mobile station 7 is input via I/O interface 64. A check is





effected through a subscriber database 69 connected to I/O interface 64 to identify whether the input subscriber is a proper predetermined subscriber.

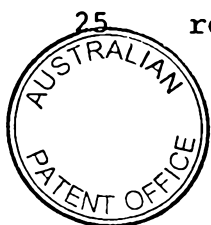
The procedure of sending a signal and receiving position information to search for the position information of mobile station 7 will be described hereinafter with reference to Figs. 10, 11 and 12. First, keyboard 11 at center station 91 is manipulated to dial automatically the PHS telephone number of mobile station 7 of interest under control of personal computer or work station 12. As shown in Fig. 10, a telephone line is connected to mobile station 7 via a repeater 6 corresponding to cell 8 in which that mobile station 7 is located through exchange station 2 and the like. When line connection is established between center station 91 and mobile station 7, the code number of the relevant repeater 6 is recognized and stored in the database of the PHS. Since this recognition and storage is carried out instantly, the line between center station 91 and mobile station 7 can be disconnected immediately. The position information of repeater 6 is represented by the code of repeater 6 or by the latitude and longitude of repeater 6. The position information is immediately sent from the PHS database to modem 13 at center station 91 and transmitted to personal computer or work station 12.



At personal computer or work station 12, map information is sent in advance from the incorporated CD-ROM drive 65. The map information is provided as a map 10 on the screen of display 61. By placing the position information represented by the code or the latitude and longitude of repeater 6 on map 10, repeater 6 can be indicated by marker 9 as shown in Fig. 11.

As described above, entry of mobile station 7 into cell 8 of repeater 6 is recognized and stored in the database. The information thereof is provided to center station 1, so that the location of mobile station 7 within the circle of approximately 100m in radius about a repeater 6 is detected.

When the position is to be determined in such a system, cell 8 is not always a circle depending upon the status around the repeater. When the PHS owner is located at a site where wave propagation is blocked by some building and the like, various wave propagation patterns according to various cases shown in Figs. 13A-13C taking account of the arrangement and profile of that building and the like is required. Here, a wave propagation pattern indicates a pattern of a region having a wave intensity emitted from a repeater exceeding a constant value taking into consideration the environmental status of the repeater. In accounting for a building structure as an



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example of environmental status of the repeater in producing a wave propagation pattern, an operator had to select the propagation pattern from the pattern shown in Figs. 13A-13C according to the position relationship between the repeater  
5 and the surrounding facility in the conventional case. The propagation pattern had to be calculated according to the selected pattern. Thus, there was a problem that computation of the wave propagation pattern is time consuming.

10 The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

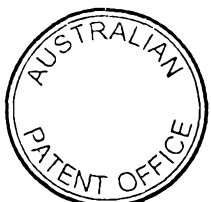
#### Summary of the Invention

15 The present invention provides an electric field intensity distribution preparation apparatus comprising:

means for dividing a neighborhood of a wave generation source into meshes of a desired size, centered about said wave generation source,

20 means for determining a predetermined type of said mesh on the basis of a map including the neighborhood of said wave generation source,

means for obtaining electric field intensity for each said mesh according to a determination result by said



determination means and a distance between said wave generation source and said mesh, and

means for preparing an electric field intensity distribution of the neighborhood of said wave generation source according to said obtained electric field intensity.

The invention also provides a mobile communication system for carrying out communication between a mobile second station and a third station via a first station, wherein said first station emits a wave of a predetermined frequency at a predetermined intensity, comprising:

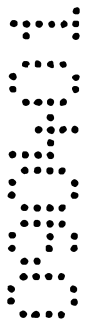
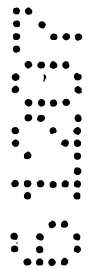
means for producing an electric field intensity distribution of a wave emitted from said first station at a neighborhood of said first station,

said means for producing an electric field intensity distribution comprises

means for dividing the neighborhood of the first station into meshes of a predetermined size, centered about said first station,

means for determining a predetermined type of said mesh on the basis of a map including the neighborhood of said first station,

means for obtaining electric field intensity for each said mesh according to a determination result by said determination means and a distance between said first



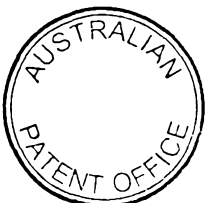
station and said mesh, and

means for producing an electric field intensity distribution of the neighborhood of said first station according to said obtained electric field intensity,

5 wherein said second station provides information identifying said first station and electric field intensity thereof to said third station when communicating with said first station,

10 wherein said third station determines a position of said second station from said provided identification information and electric field intensity of said first station, and said electric field intensity distribution.

15 A wave intensity distribution production apparatus of one embodiment of the invention includes means for dividing the neighborhood about a wave generation source into meshes of a desired size, means for determining a predetermined type of the mesh on the basis of a map including the neighborhood of the wave generation source, means for obtaining electric field intensity of the mesh according to  
20 the determination result by said determination means



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and the electric field intensity of the wave generation source, and means for producing an electric field intensity distribution of the neighborhood of the wave generation source according to the obtained electric field intensity.

5           The neighborhood of the wave generation source is divided into meshes of a desired size. Each divided mesh is determined corresponding to a predetermined type according to the electronic map. The electric field intensity of each mesh is obtained according to the determination result and

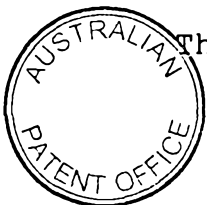
10 the electric field intensity from the wave generation source. An electric field intensity distribution of the neighborhood of the wave generation source is produced according to the electric field intensity. Since the electric field intensity distribution is produced taking

15 into consideration the actual geometry of the wave generation source, a wave propagation pattern of the neighborhood of the wave generation source can be easily determined.

          According to another embodiment of the present

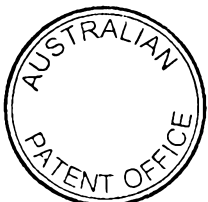
20 invention, a mobile communication system carries out communication between a moving second station and a third station via a first station. The first station emits a wave of a predetermined frequency at a predetermined intensity.

The mobile communication system includes means for producing



the electric field intensity distribution of the wave emitted from the first station at the neighborhood of the first station. The means for producing an electric field intensity distribution includes means for dividing the neighborhood about the first station into meshes of a  
5 desired size, means for determining a predetermined type for the mesh on the basis of a map including the neighborhood of the first station, means for obtaining the electric field intensity for each mesh according to the  
10 determination result by the determination means and the distance between the first station and the mesh, and means for producing an electric field intensity distribution of the neighborhood of the first station according to the obtained electric field intensity. The second station  
15 provides the information for identifying the first station and the electric field intensity thereof at the time of communication with the first station to the third station. The third station determines the position of the second station from the identification information and the  
20 electric field intensity of the first station sent from the second station, and an electric field intensity distribution.

In a mobile communication system that carries out communication between a moving second station and a third  
25 station via a first station, the electric field intensity



distribution of the neighborhood of the first station from which the wave is emitted is produced for every predetermined mesh. In communication with the third station, the second station provides the electric field intensity of  
 5 the first station. From the electric field intensity and the electric field intensity distribution, the position of the second station is determined at the third station. Thus, a mobile communication system that can easily determine the position of a second station in a short time  
 10 can be provided.

#### Brief Description of the Drawings

Fig. 1A is a block diagram showing a structure of a center station of a position determination system of an embodiment of the invention, and Fig. 1B is a diagram  
 15 showing contents of data of a repeater electric field intensity distribution database.

Fig. 2 is a flow chart indicating the procedure of producing an electric field intensity distribution centered about a repeater.

20 Fig. 3 is a diagram showing a concept of meshes centered about a repeater.

Fig. 4 is a diagram showing a concept of meshes with and without sight.

Fig. 5 is a diagram showing a mesh determination method  
 25 taking into consideration the height direction of a





building structure.

Fig. 6 is a diagram showing an electric field intensity distribution of a repeater.

Fig. 7 is a diagram showing a wave propagation  
5 pattern when the electric field intensity is 20 decibels.

Fig. 8 is a diagram showing measured value data between electric field intensity and distance.

Fig. 9 is a diagram showing measured value data between electric field intensity and distance.

10 Fig. 10 is a block diagram showing an entire structure of a position display system of a mobile terminal.

Fig. 11 is a block diagram showing a structure of a center station.

15 Fig. 12 is a block diagram showing a structure of a center station.

Figs. 13A-13C show the relationship with the wave propagation pattern of a building structure.

20 Fig. 14 shows a specific example of position identification using an electric field intensity distribution.

Fig. 15 is a diagram showing an example of position identification using an electric field intensity distribution.

25 Fig. 16 is a diagram showing an example of position



identification using an electric field intensity distribution.

Fig. 17 is a diagram showing an example of position identification using an electric field intensity

5 distribution.

Figs. 18A and 18B are diagrams showing measurement examples of a delay profile for determination of a direct wave.

Preferred Embodiments of the Invention

10 Preferred embodiments of the present invention will be described hereinafter with reference to the drawings. Fig. 1A is a block diagram of a center station 1 using the positioning system of the present invention. In contrast to the conventional case of Fig. 12, provision of an electric field intensity distribution database 81 in which an  
15 electronic map 81a and a repeater electric field intensity distribution database 81b are integrally formed differs from the conventional center station 91. The data contents of the repeater electric field intensity distribution database  
20 are shown in the drawing. The data contents of the repeater electric field intensity distribution database are shown in Fig. 1B. As shown in Fig. 1B, the repeater electric field

intensity distribution database includes the ID of respective repeaters, the latitude and longitude information



indicating the position, and electric field intensity distribution data for each mesh at the neighborhood of that repeater. The remaining elements are similar to those of the conventional case. Corresponding elements have the same reference characters allotted, and their description will not be repeated.

5 A mobile terminal detects the identification information ID of a plurality of repeaters and electric field intensity. This information is sent to center station 1. Center station 1 obtains the region where the mobile terminal can be located with respect to each electric field intensity using the electric field intensity distribution of each repeater obtained in advance from the identification information and electric field intensity of the plurality of repeaters. The position of the mobile terminal is detected from the overlap of each region.

(1) Production of electric field intensity distribution of neighborhood of repeater

20 Description is provided of how center station 1 obtains the electric field intensity distribution of the neighborhood of repeater 6.

Fig. 2 is a flow chart of obtaining an electric field intensity distribution of the neighborhood of repeater 6.

25 Figs. 3-6 are diagrams describing the steps of obtaining



an electric field intensity distribution. The method of obtaining electric field intensity distribution of repeater 6 will be described with reference to Figs. 2-6.

As shown in Fig. 3, a mesh of an arbitrary size about  
5 a repeater is defined as the region required to produce a wave propagation pattern. Here, this mesh becomes the unit in producing an electric field intensity distribution. The size of the mesh and the size of the region defining the mesh are defined within a tolerable range of precision and  
10 data size.

Referring to Fig. 3, a mesh 101 is formed at the neighborhood of repeater station 6. Then, referring to electronic map 81a, the shape of the building that becomes an obstacle for the wave is formed as a building polygon  
15 111 in the region where mesh 101 is formed (in Fig. 2, step S11: "step" omitted hereinafter).

Each divided mesh is subjected to a process set forth in the following. When the center point of that mesh is located within building polygon 111 on electronic map 81a,  
20 that mesh is set as a mesh with no wave propagation. When the center point of the mesh is outside building polygon 111, the crossing point between building polygon 111 and the line connecting the center points of repeater 6 and the mesh is obtained (S12-S15). When there is no crossing  
25 point, that mesh is set as a mesh A with good wave

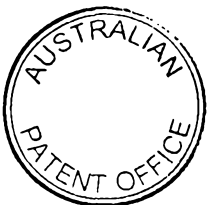


propagation. When there is a crossing point, that mesh is set as a mesh B with poor wave propagation. The mesh inside building polygon 111 is set as a mesh C with no wave propagation. A specific example is shown in Fig. 4.

5 Even if there is a crossing point with building polygon 111, the mesh is set as a mesh with good wave propagation when the height of the building is lower than the difference in height from repeater 6 to the center point of the mesh. The height of the building is obtained using  
10 the information of the number of stories of that building and the like on electronic map 81a.

An example of this case is shown in Fig. 5. Referring to Fig. 5, when repeater 6 is on a building 112, the mesh is set as a mesh with good wave propagation when a  
15 straight line 116 connecting repeater 6 with the mesh center point 115, indicating the change in height, does not cross building 117.

The electric field intensity of each mesh is obtained using a relation equation of an electric field intensity and wave propagation distance on the basis of the distance  
20 between the center point of the repeater and the center point of each mesh (S16). The equation of the relationship between electric field intensity and wave propagation distance is produced for each type of repeater 6 depending  
25 upon whether the wave propagation is superior or not and



whether is provided on a telephone booth, a pole, or the roof of a building structure. Also, wave reflection and waveguide effect due to the state of the building around the mesh in obtaining the electric field intensity of each mesh are taken into account.

An electric field intensity distribution of a repeater is produced according to each obtained mesh electric field intensity (S17). An example of the electric field intensity distribution of the repeater is shown in Fig. 6. In Fig. 6, the bold numeric in the mesh indicates a mesh with good wave propagation, and a numeric represented in a slanted manner indicates a mesh with poor wave propagation. The electric field intensity distribution is obtained in a similar manner for all the repeaters. A database is produced that can be retrieved by entering the ID of repeater 6.

The method of determining the position using this database will be described hereinafter.

A specified repeater 6 is retrieved from electric field intensity distribution database 81b. A group of meshes having an electric field intensity of at least an arbitrary value is set as the wave propagation pattern of an arbitrary electric field intensity. This example is shown in Fig. 7. The shaded area in Fig. 7 represents the wave propagation pattern. Here, the wave propagation

25



pattern when the electric field intensity is 20dB is shown. By setting the electric field intensity to a desired value, a wave propagation pattern of a desired intensity can be obtained.

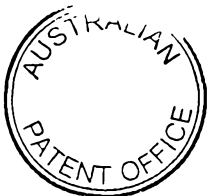
5           The method of obtaining each mesh electric field intensity of S16 will be described hereinafter. Figs. 8 and 9 are graphs indicating the measured results of the distance from each repeater 6 and the reception electric field intensity when wave propagation is good (Fig. 8) and  
10           poor (Fig. 9). This corresponds to the case where the repeater corresponds to a telephone booth. The equation of the relationship between the electric field intensity and the maximum wave propagation distance is obtained from the graph to result in the following equations.

15           Propagation distance  $N(m) = - (\text{electric field intensity (dB)} - 82)/0.056 \dots$  (when wave propagation is good).

            Propagation distance  $N(m) = - (\text{electric field intensity (dB)} - 82)/0.112 \dots$  (when wave propagation is  
20           poor).

            Electric field intensity for each mesh is obtained according to the above equation for both cases of good and poor wave propagation.

            The wave propagation pattern of an arbitrary electric  
25           field intensity can be obtained from the wave propagation



pattern for each intensity of repeater 6 and an arbitrary electric field intensity stored in data base 81 without having to obtain the crossing point with the building data on the electronic map every time.

5           Also, the computation time for obtaining a wave propagation pattern of an arbitrary electric field intensity is reduced since the crossing with the building data on the map is not obtained every time.

10           It is not necessary to obtain the crossing point with the building data on the electric map for each measurement since the electric field intensity of an arbitrary position centered about repeater 6 is stored in database 81b. Therefore, the computation time for obtaining the wave propagation pattern of an arbitrary electric field is  
15 reduced.

          The wave employed in the present invention is described hereinafter. The wave used for communication with a repeater is preferably a direct wave, not a reflected wave or the like. A method of determining this  
20 direct wave will be described hereinafter.

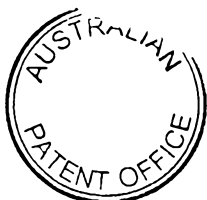
          Figs. 18A and 18B show a wave delay profile with the delay time of the wave arriving at respective points plotted along the abscissa and the power of each wave plotted along the ordinate. Fig. 18A corresponds to the  
25 case where a direct wave is received. Fig. 18B corresponds





to the case where a direct wave is not received. Referring to Figs. 18A and 18B, the wave with the shortest delay time is the wave that arrives from the transmitted point through the shortest distance. A wave with a longer delay time is a wave that arrives at a reception point through reflection and diffraction. Since the distance to the reflected-diffracted point is altered as the distance of travel increases, the delay profile is altered according to the travel. When the direct wave is received within the sight where the wave is received directly, the wave with the shortest delay time is set as the direct wave from the delay profile. However, there is a case where the direct wave cannot be received by being blocked by the shadow of a facility such as the building. In this case, determination is made whether a direct wave is received or not using a delay spread property. This delay spread represents the spread of the delay time by rendering the area of the shaded region in Fig. 18B constant (normalized). According to the spread of the delay time of this delay spread property, determination can be made that a direct wave is received when the spread is small, and a direct wave is not received when the spread is great.

The waveform shown in Figs. 18A and 18B can be obtained by separating the components of the arriving wave (direct wave, reflected wave and the like) by a traversal

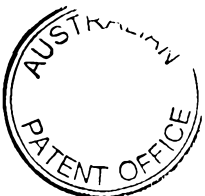


filter or a filter used in RAKE reception.

In the above embodiment, the position of the mobile terminal is determined by obtaining the electric field intensity distribution at one repeater. The present invention is not limited to the above embodiment, and the positioning can be made more precise by using an electric field intensity distribution obtained from a plurality of repeaters. In this case, the position of respective meshes is identified by the latitude and longitude information of the repeater ID. Therefore, the position of the mobile terminal can be easily detected by comparing the electric field intensity distribution of respective repeaters for each mesh.

An example of this case will be described with reference to Figs. 14-17. Figs. 14-16 show meshes having an electric field intensity exceeding a predetermined value on the basis of respective repeaters 6A-6C. By obtaining the overlapping area on the basis of the data from these three repeaters, the precise position of the mobile terminal can be identified as shown in Fig. 17.

In the above embodiment, center station 1 receives information of repeater 6 from control station 51 by establishing communication between center station 1 and mobile station 7. The present invention is not limited to the above embodiment, and the repeater database can be



provided at center station 1. Information of the neighborhood of repeater 6 can be received from mobile station 7. The repeater can be identified at center station 1 according to the received information. In this case, the  
5 database of center station 1 includes the ID for identifying a repeater and the position information.

#### Industrial Applicability

Since the electric field intensity distribution preparation apparatus of the present invention can easily  
10 determine a wave propagation pattern centered about a repeater, it is applicable to usage in a position determination apparatus employing a wave.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word  
15 "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.



## Claims

1. An electric field intensity distribution preparation apparatus comprising:

- 5           means for dividing a neighborhood of a wave generation source into meshes of a desired size, centered about said wave generation source,
- means for determining a predetermined type of said mesh on the basis of a map including the neighborhood of
- 10          said wave generation source,
- means for obtaining electric field intensity for each said mesh according to a determination result by said determination means and a distance between said wave generation source and said mesh, and
- 15          means for preparing an electric field intensity distribution of the neighborhood of said wave generation source according to said obtained electric field intensity.

2. The electric field intensity distribution preparation apparatus according to claim 1, wherein the

20          type of a mesh determined by said determination means includes a first region of good sight from said wave generation source and a second region of poor sight.

25          3. The electric field intensity distribution



preparation apparatus according to claim 2, wherein said means for obtaining electric field intensity for each mesh is carried out according to the distance from said wave generation source and an actually measured value of  
5 reception electric field intensity of that distance.

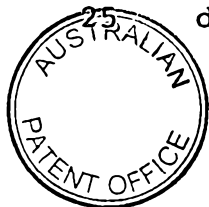
4. The electric field intensity distribution preparation apparatus according to claim 2, wherein said means for obtaining electric field intensity for each mesh  
10 is carried out using

propagation distance  $N(m) = - (\text{electric field intensity (dB)} - 82) / 0.056$  for said first region, and

propagation distance  $N(m) = - (\text{electric field intensity (dB)} - 82) / 0.112$  for said second region.  
15

5. The electric field intensity distribution preparation apparatus according to claim 2, wherein said second region includes a third region where a wave is not reached.  
20

6. The electric field intensity distribution preparation apparatus according to claim 1, wherein said means for dividing into meshes determines said desired size by a precision of said electric field intensity distribution.



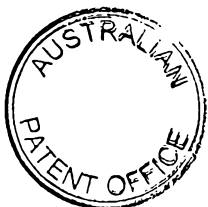
7. The electric field intensity distribution preparation apparatus according to claim 1, wherein said means for obtaining electric field intensity is carried out taking into consideration reflection of a wave from  
5 said wave generation source due to a building structure at the neighborhood of said mesh.

8. The electric field intensity distribution preparation apparatus according to claim 1, comprising  
10 means for storing said produced electric field intensity distribution.

9. The electric field intensity distribution preparation apparatus according to claim 1, wherein a  
15 plurality of said wave generation sources are provided, and said means for producing electric field intensity distribution produces said electric field intensity distribution for said plurality of wave generation sources.

20 10. The electric field intensity distribution preparation apparatus according to claim 9, comprising means for storing said produced plurality of electric field intensity distributions.

25 11. The electric field intensity distribution



preparation apparatus according to claim 10, wherein said storing means stores said produced plurality of electric field intensity distributions as a database.

5           12. The electric field intensity distribution preparation apparatus according to claim 1, wherein said wave generation source is a repeater of a communication system.

10           13. The electric field intensity distribution preparation apparatus according to claim 12, wherein said communication system includes a mobile communication system that effects communication with said repeater as a base.

15           14. A mobile communication system for carrying out communication between a mobile second station and a third station via a first station, wherein said first station emits a wave of a predetermined frequency at a  
20           predetermined intensity, comprising:

          means for producing an electric field intensity distribution of a wave emitted from said first station at a neighborhood of said first station,

          said means for producing an electric field intensity  
25           distribution comprises



means for dividing the neighborhood of the first station into meshes of a predetermined size, centered about said first station,

5 means for determining a predetermined type of said mesh on the basis of a map including the neighborhood of said first station,

means for obtaining electric field intensity for each said mesh according to a determination result by said determination means and a distance between said first station and said mesh, and

10

means for producing an electric field intensity distribution of the neighborhood of said first station according to said obtained electric field intensity,

wherein said second station provides information identifying said first station and electric field intensity thereof to said third station when communicating with said first station,

15

wherein said third station determines a position of said second station from said provided identification information and electric field intensity of said first station, and said electric field intensity distribution.

20

15. The mobile communication system according to claim 14, comprising a plurality of said first stations, wherein said second station carries out communication

25





via said plurality of first stations,

wherein said electric field intensity distribution producing means produces electric field intensity of the neighborhood of said plurality of first stations,

5 wherein said second station provides information identifying said plurality of first stations and electric field intensity thereof to said third station when communicating with said plurality of first stations,

wherein said third station determines a position of  
10 said second station from said provided information of identifying said plurality of first stations and electric field intensity thereof, and said electric field intensity distribution.

15 16. An electric field intensity distribution preparation apparatus substantially as hereinbefore described with reference to Figures 1 to 9 and 13 to 18.

17. A mobile communication system substantially as  
20 hereinbefore described with reference to Figures 1 to 9 and 13 to 18.

DATED this 9<sup>th</sup> day of April, 2001

**LOCUS CORPORATION**

25 by its Patent Attorneys

DAVIES COLLISON CAVE

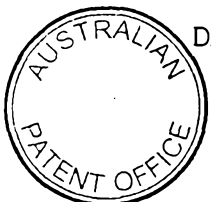


FIG. 1A

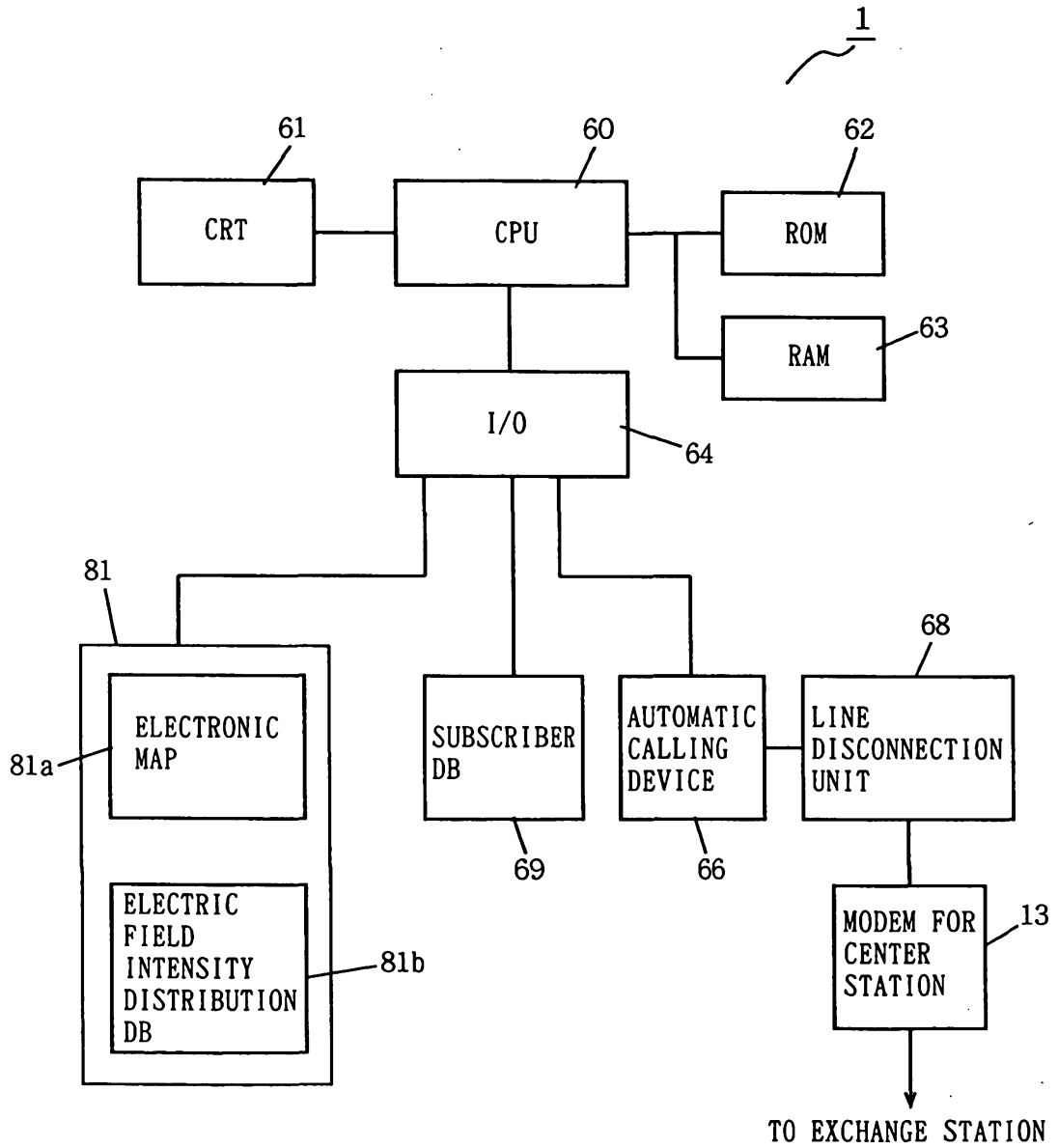


FIG. 1B

REPEATER ID	LATITUDE LONGITUDE INFORMATION	ELECTRIC FIELD INTENSITY DISTRIBUTION DATA
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FIG. 2

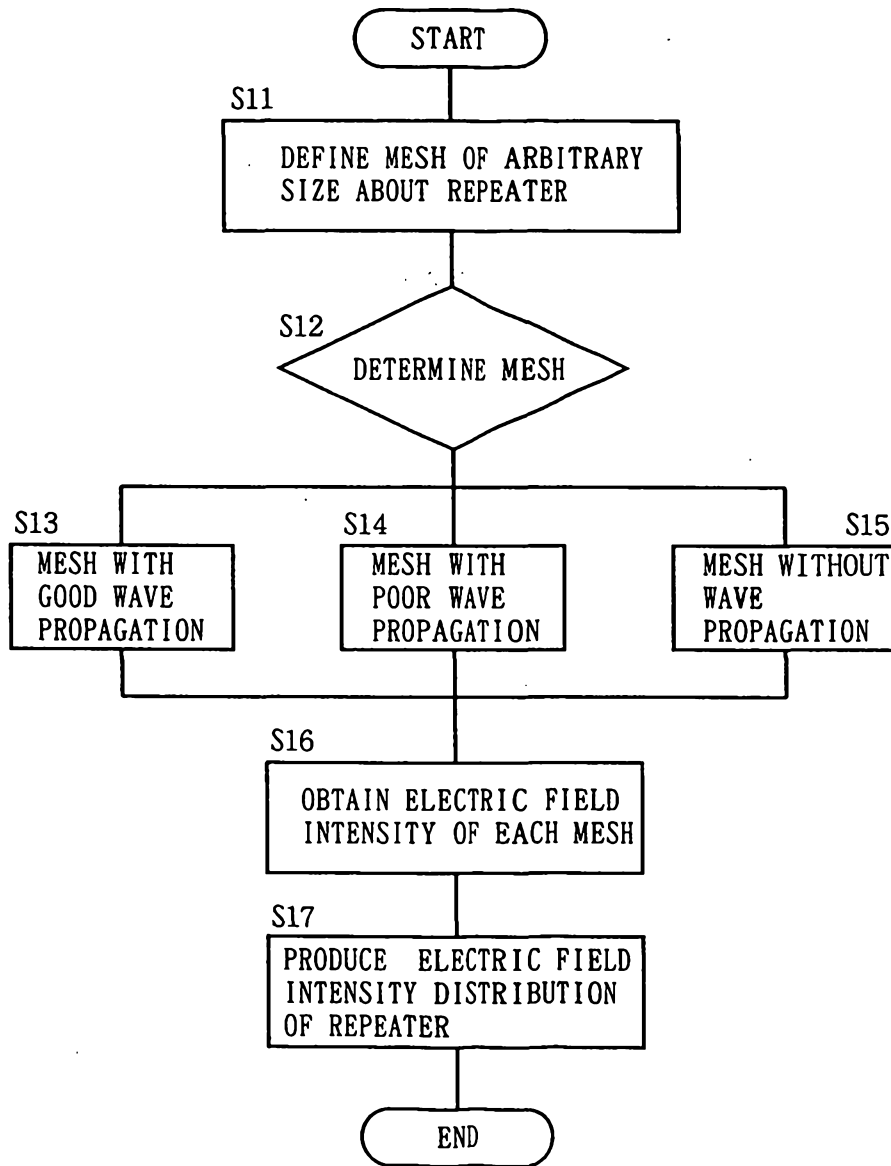


FIG. 3

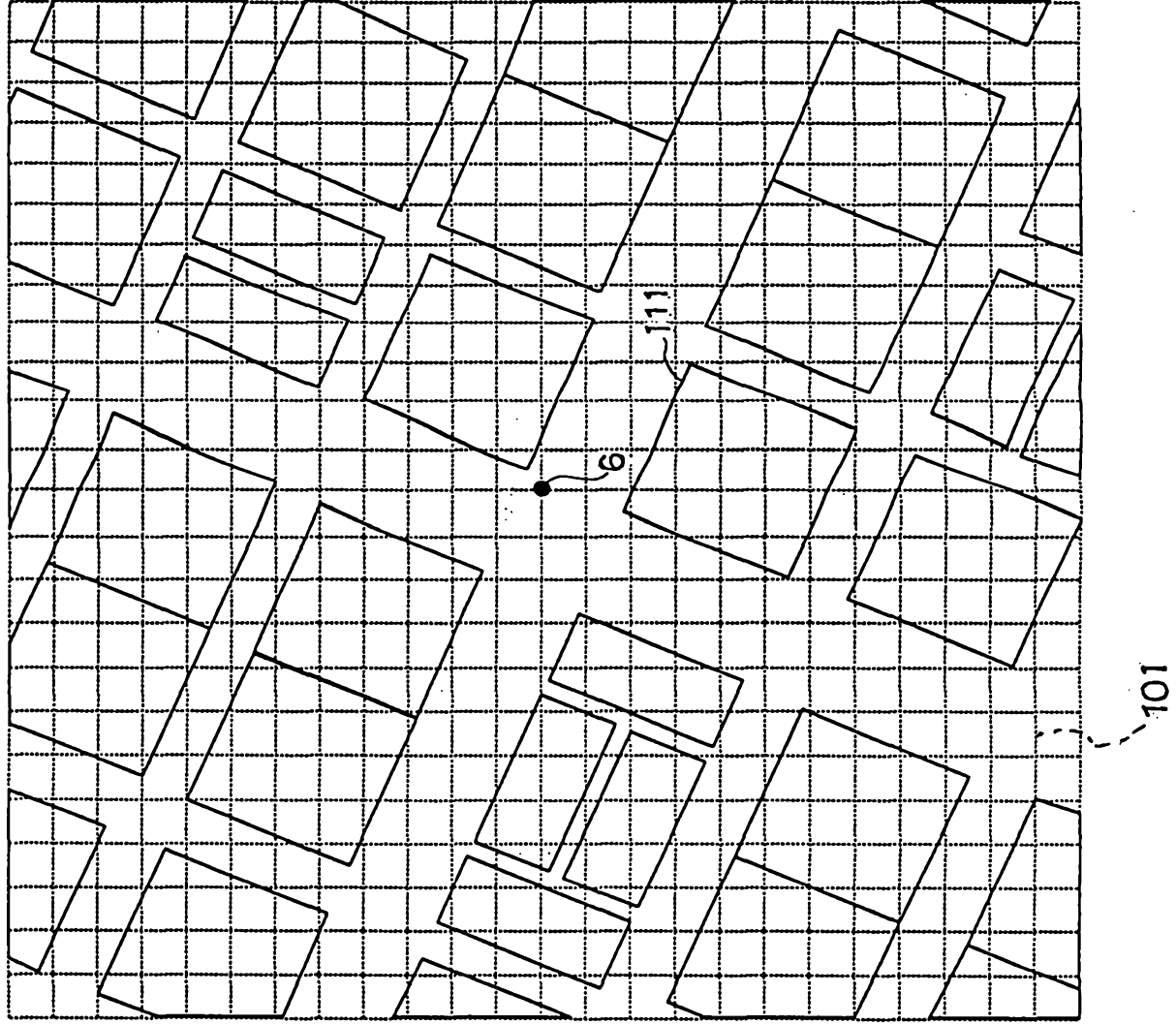


FIG. 4

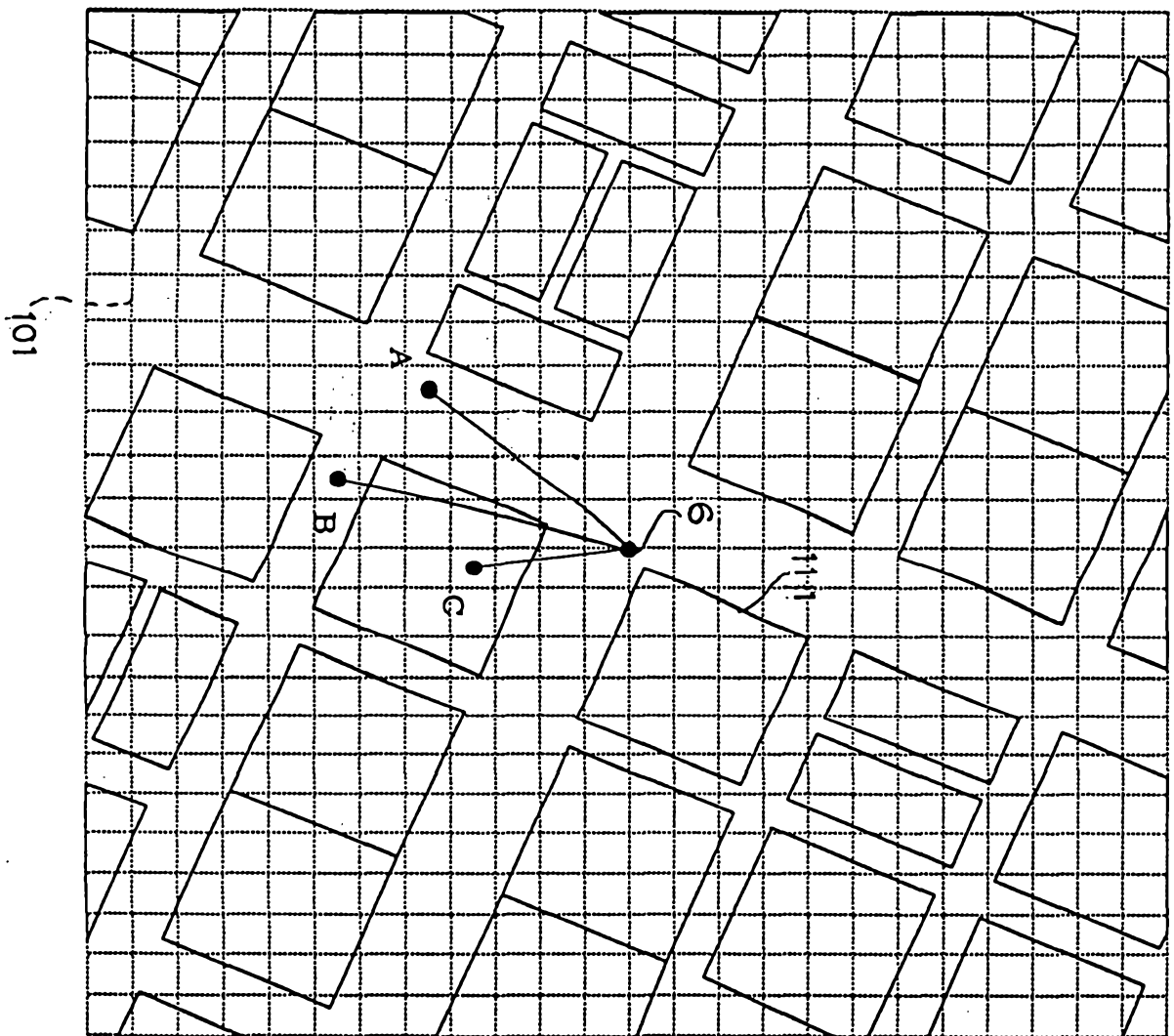


FIG. 5

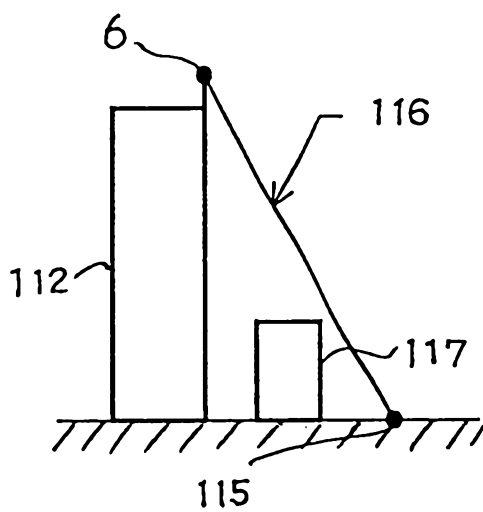


FIG. 6

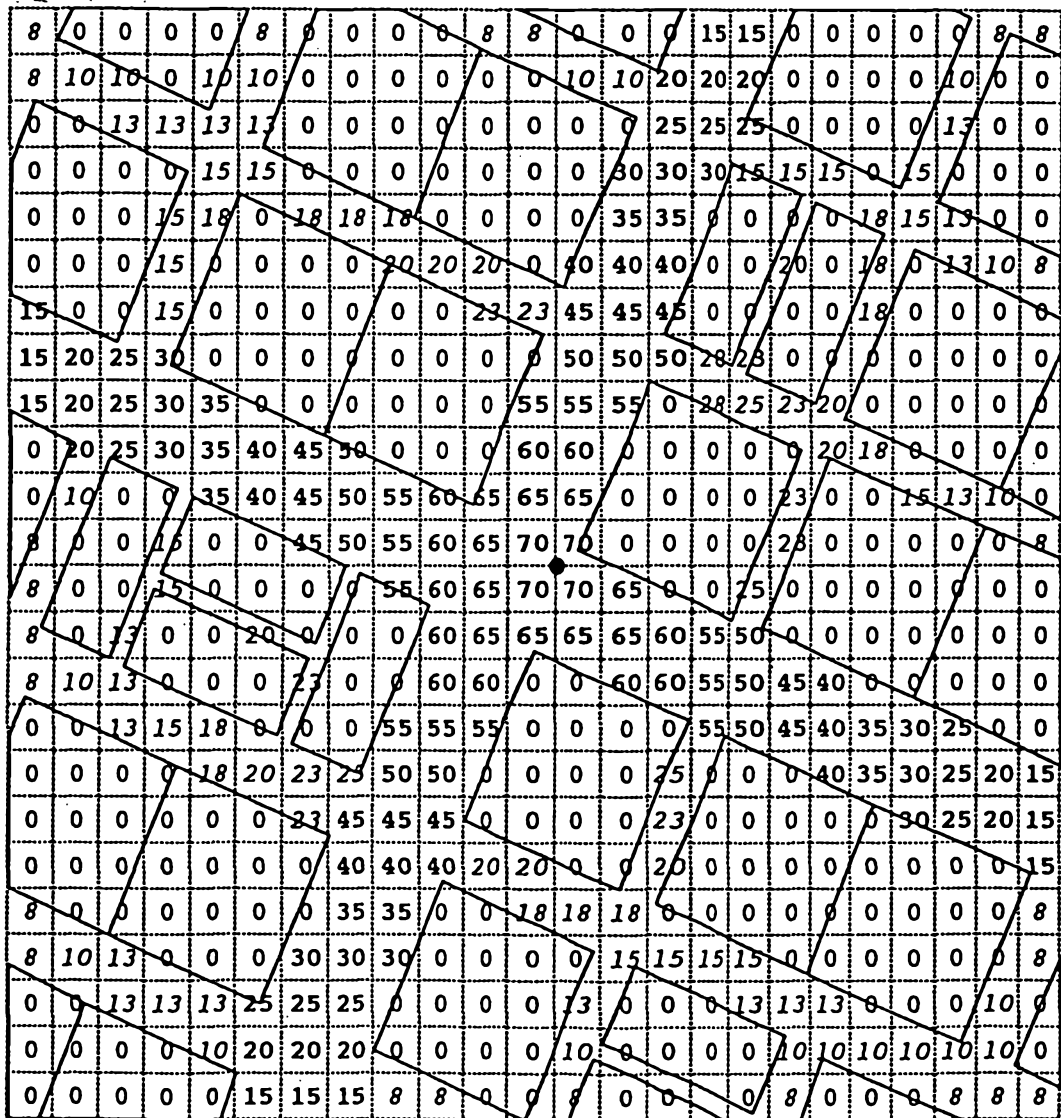


FIG. 7

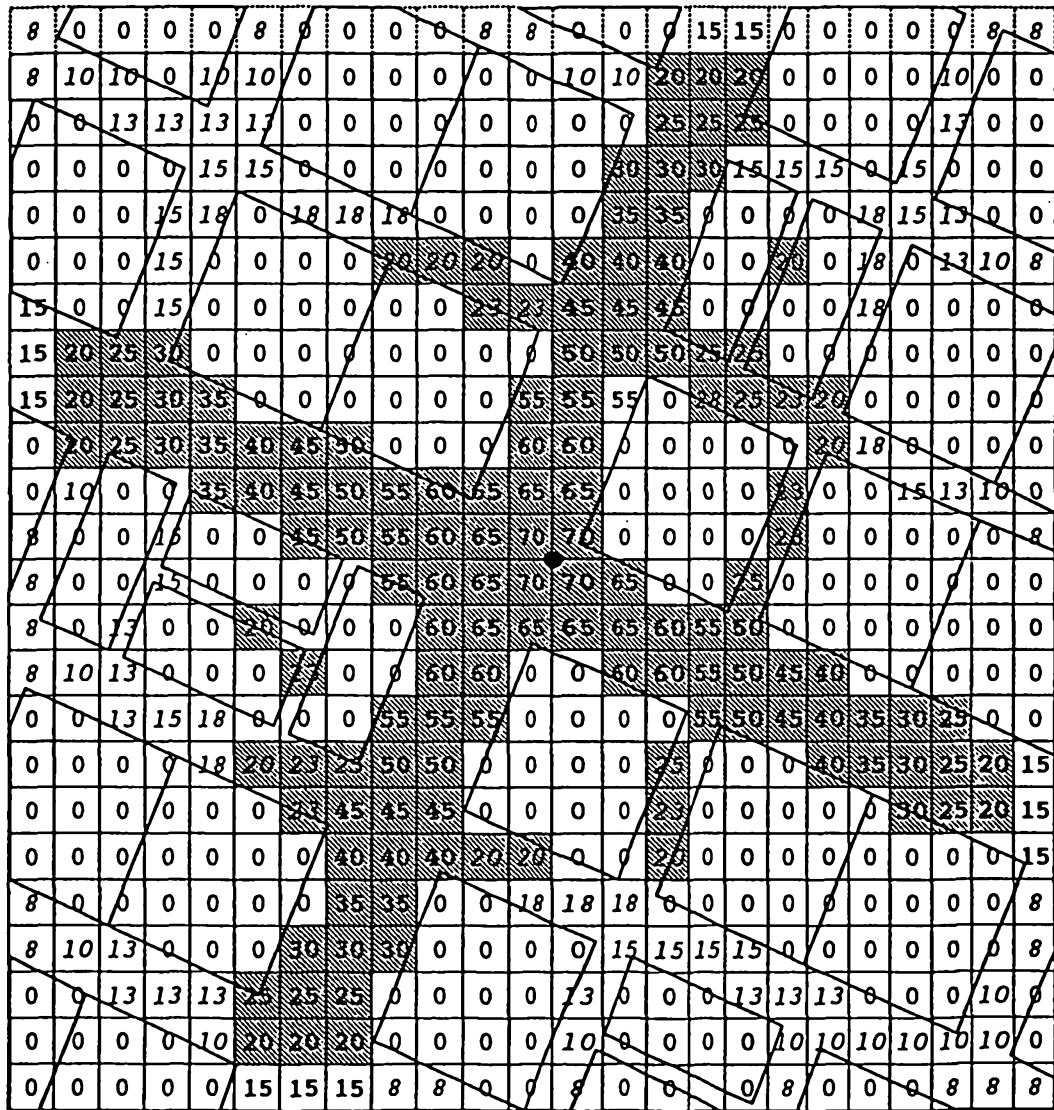




FIG. 8

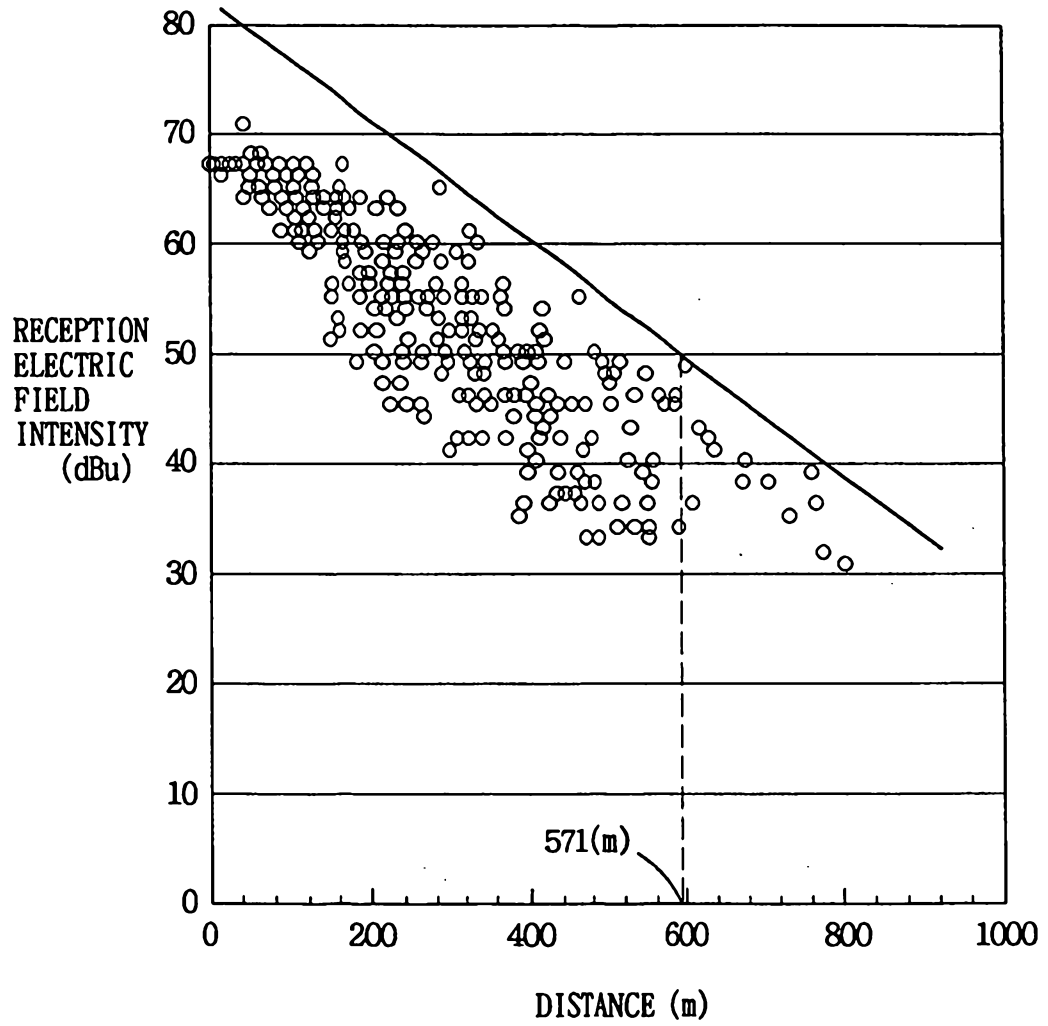


FIG. 9

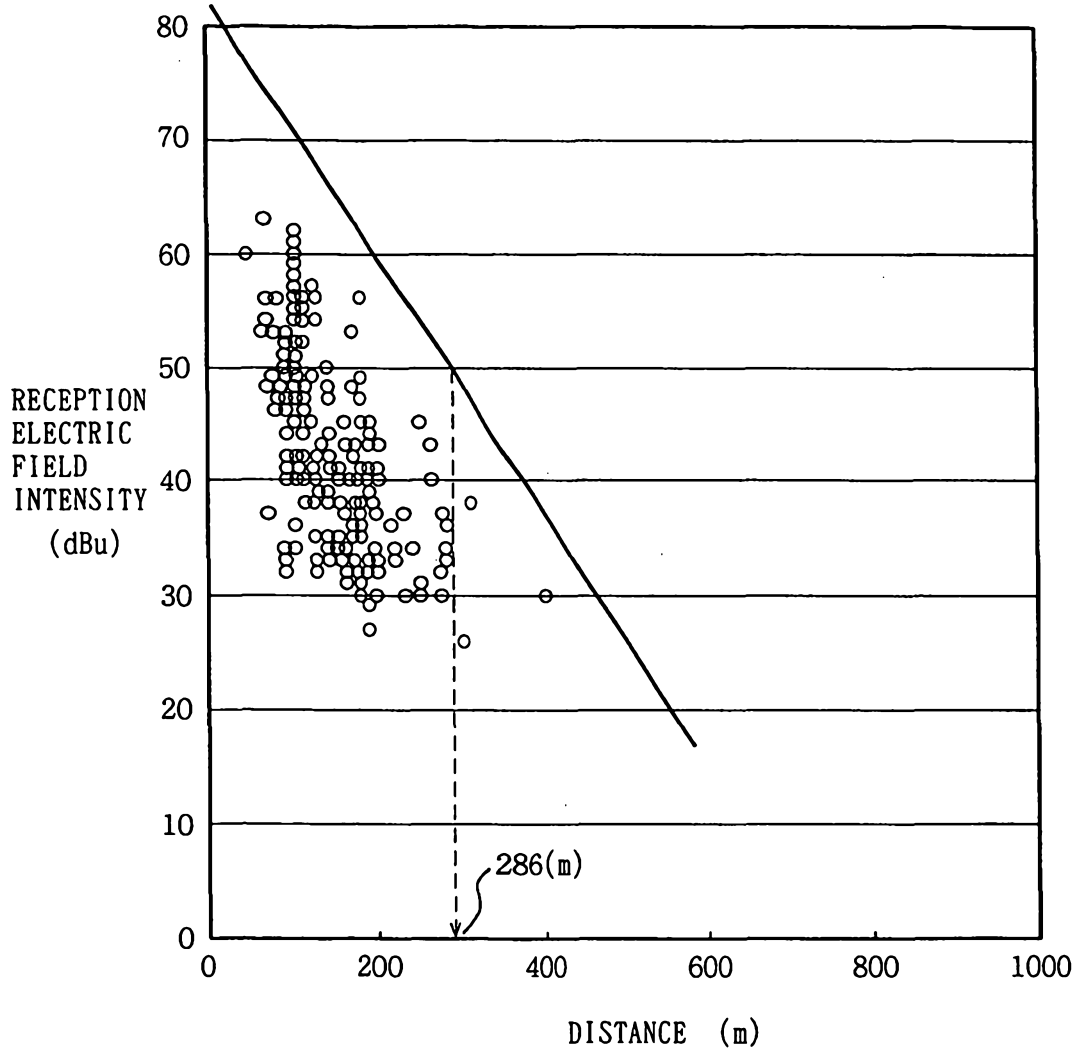


FIG. 10

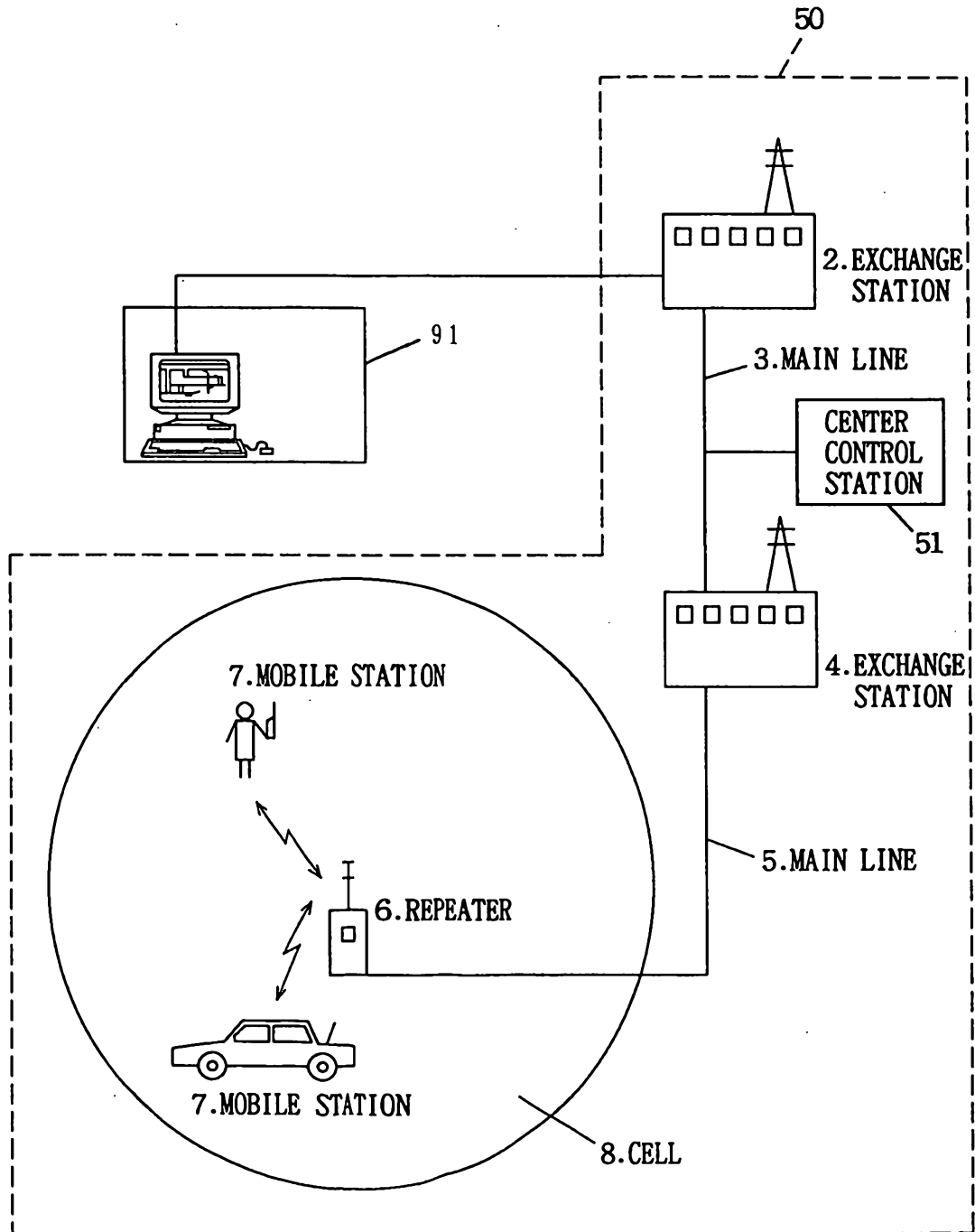


FIG. 11

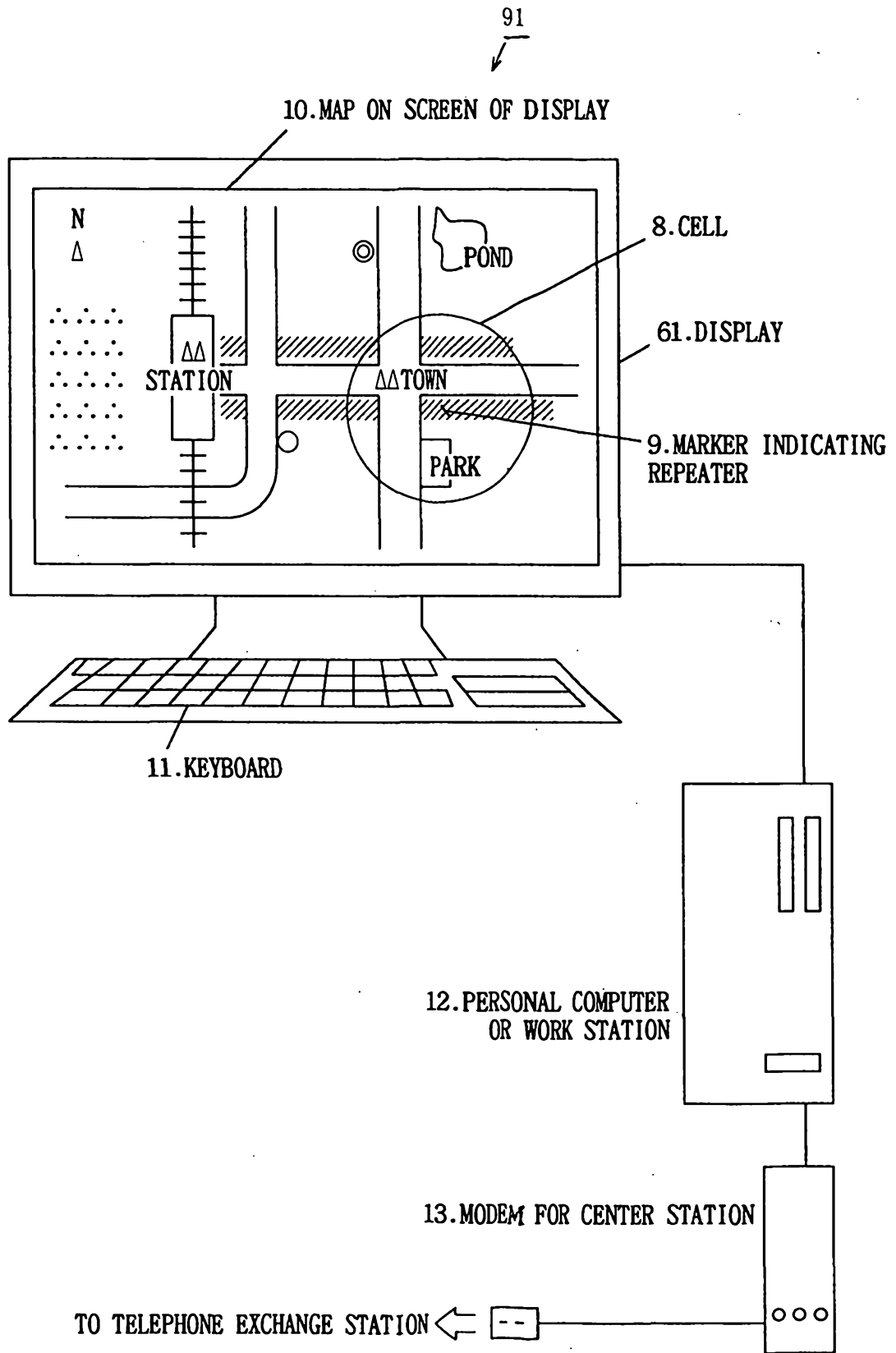


FIG. 12

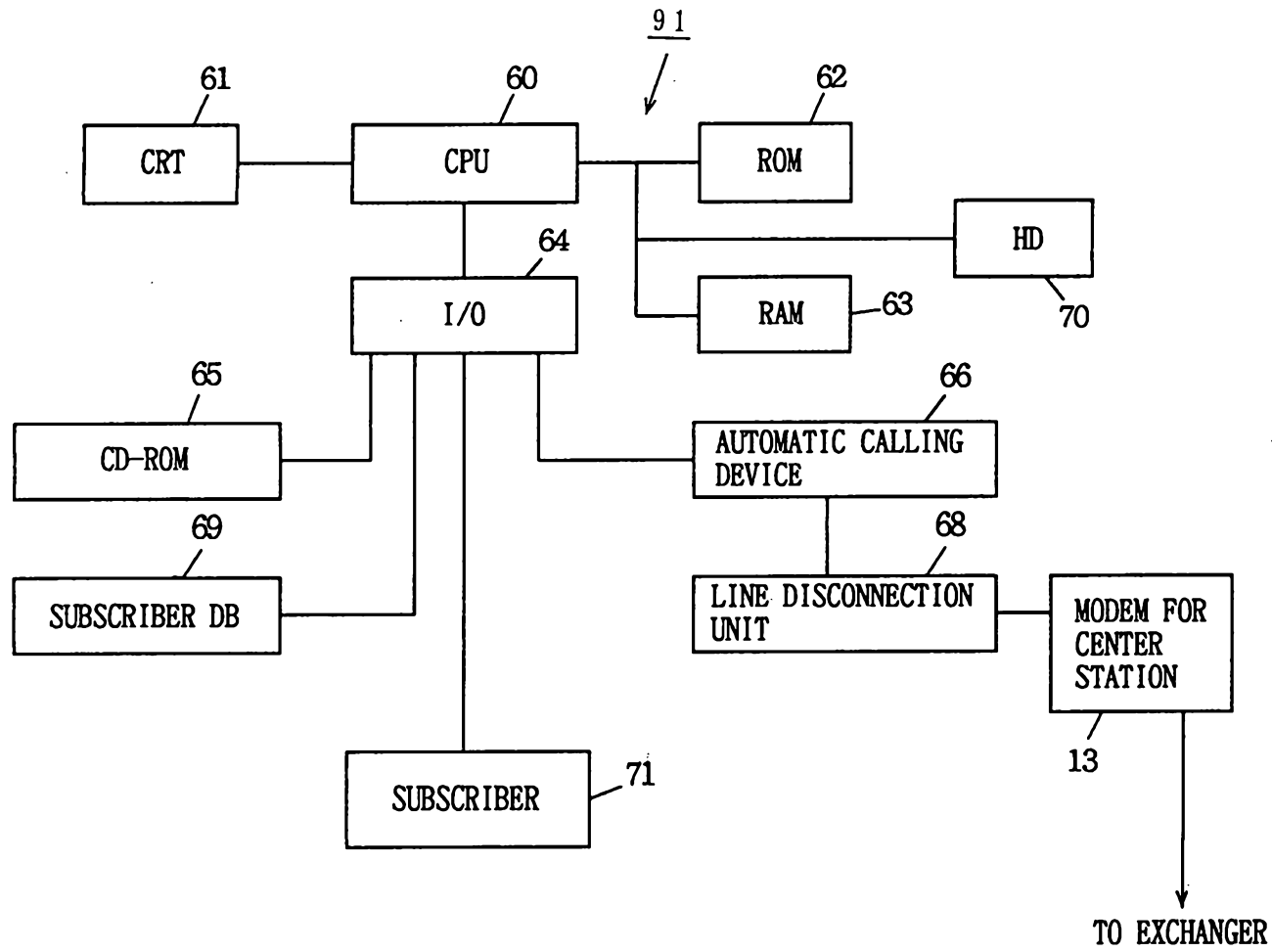


FIG. 13A

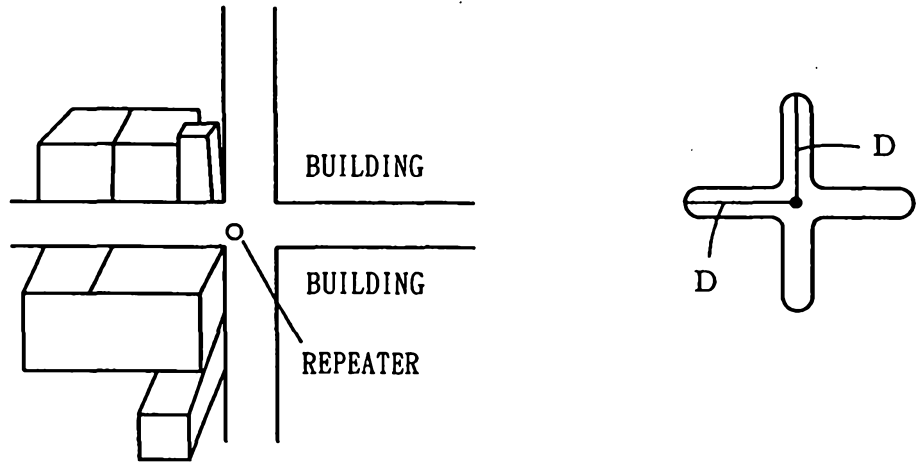


FIG. 13B

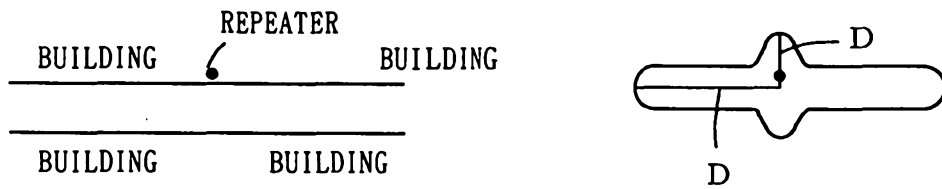


FIG. 13C

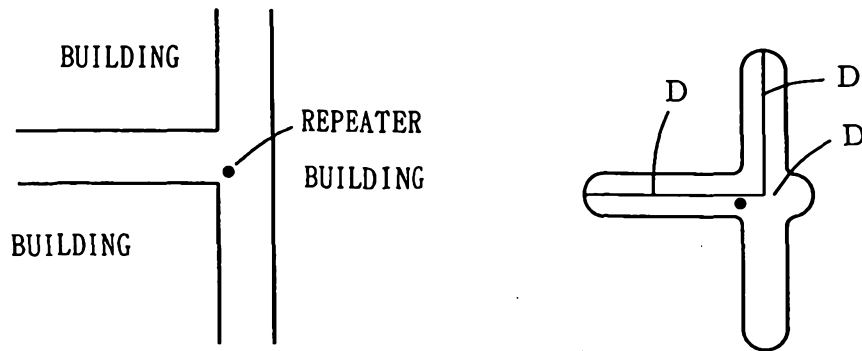


FIG. 14

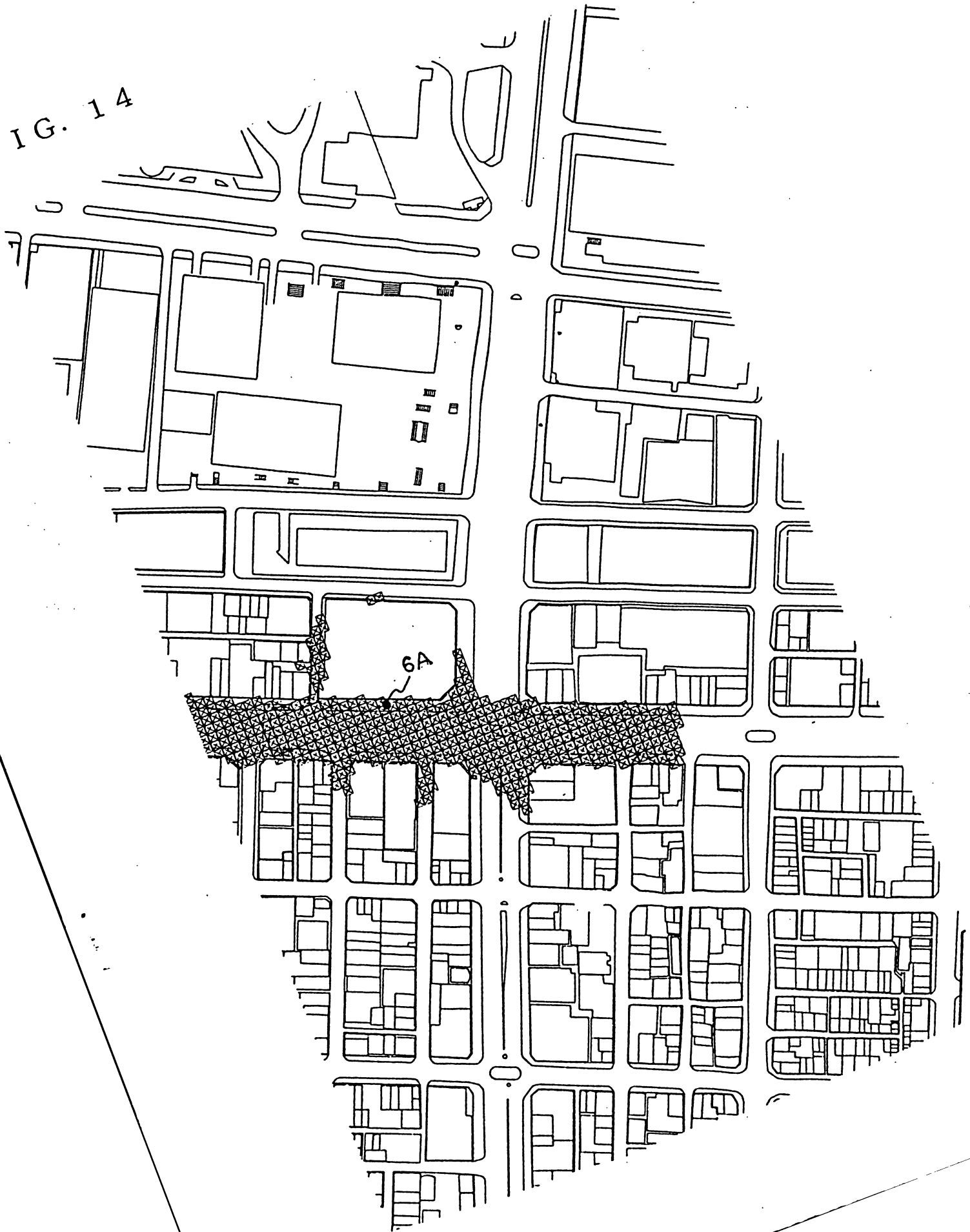


FIG. 15

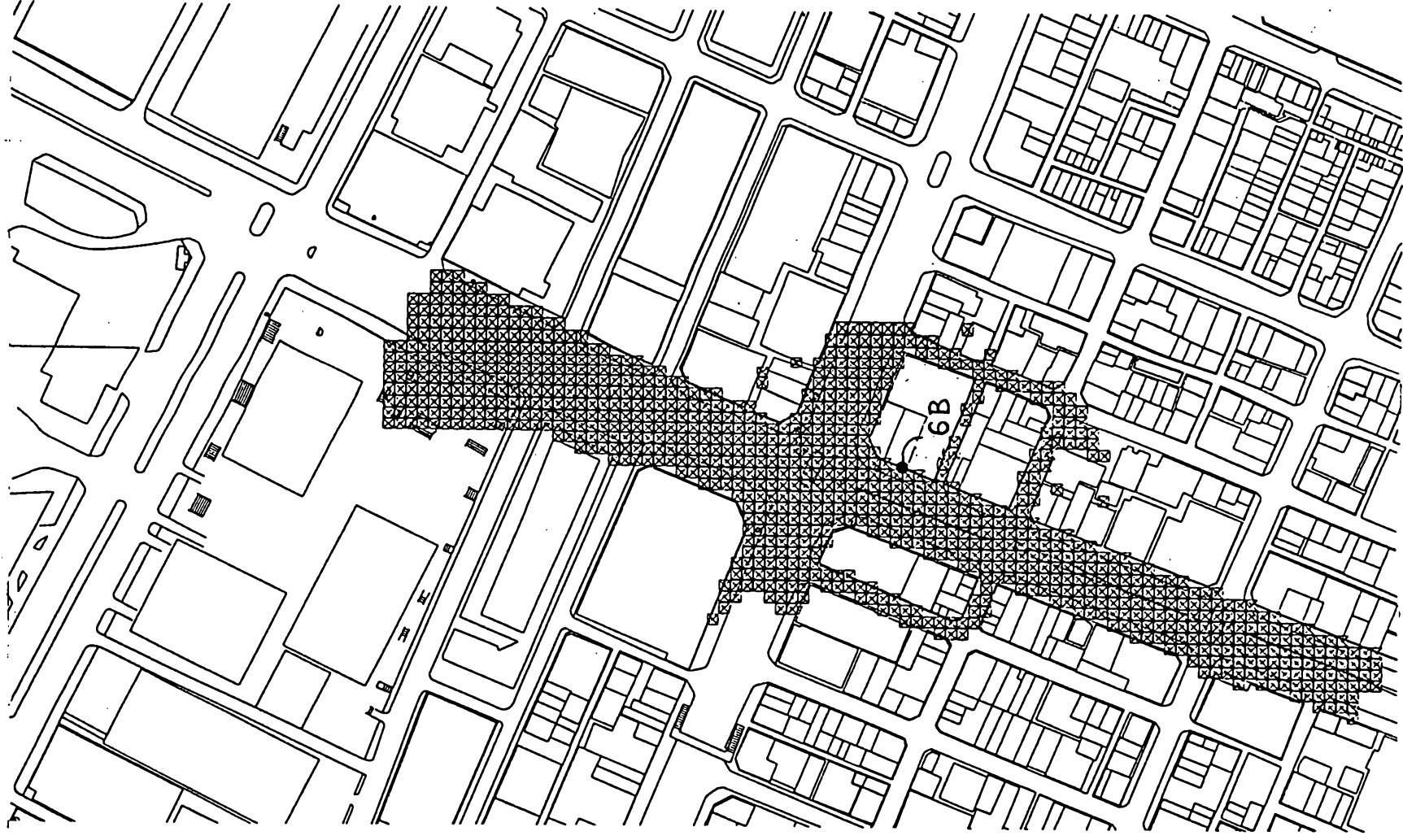




FIG. 16

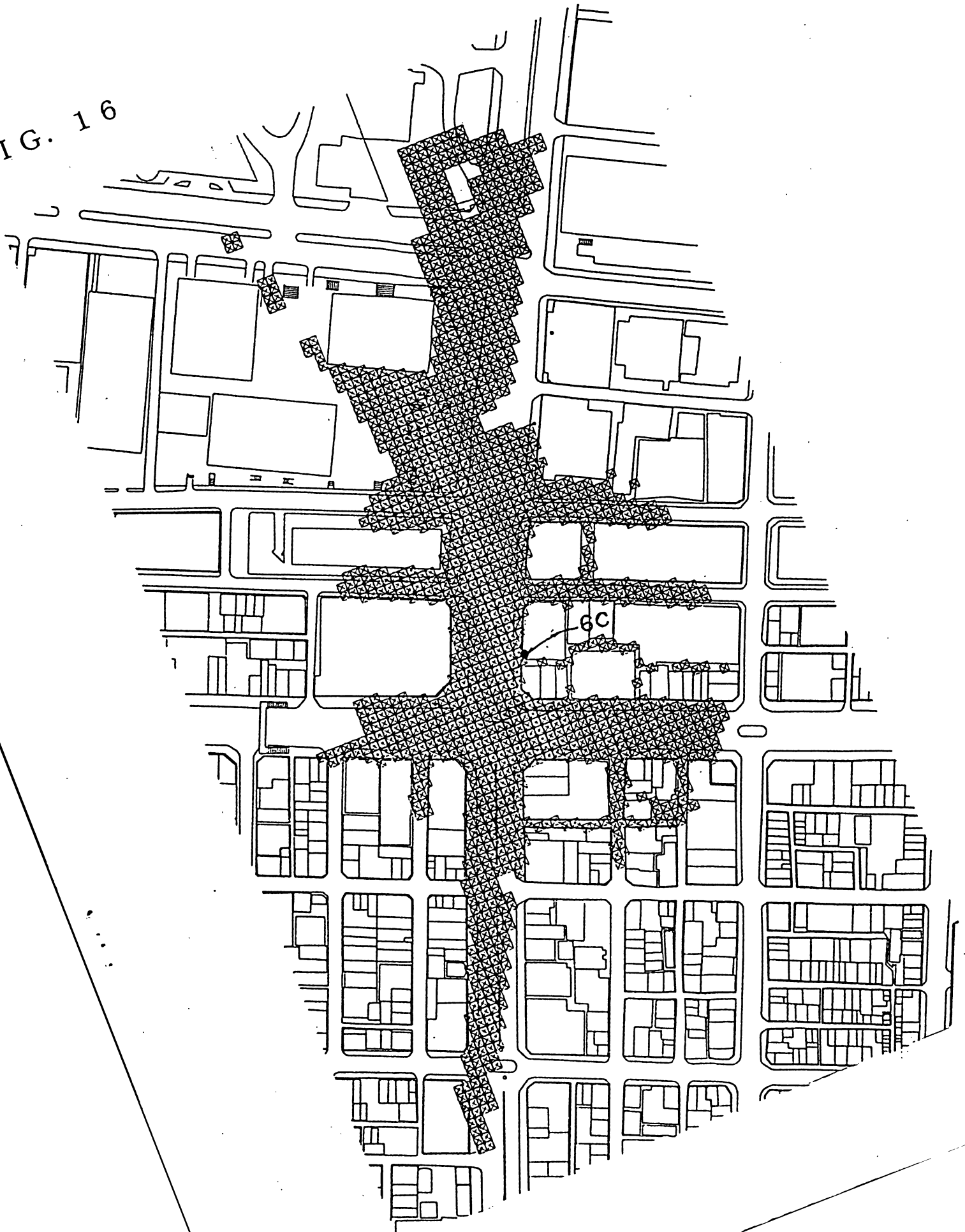


FIG. 17



FIG. 18A

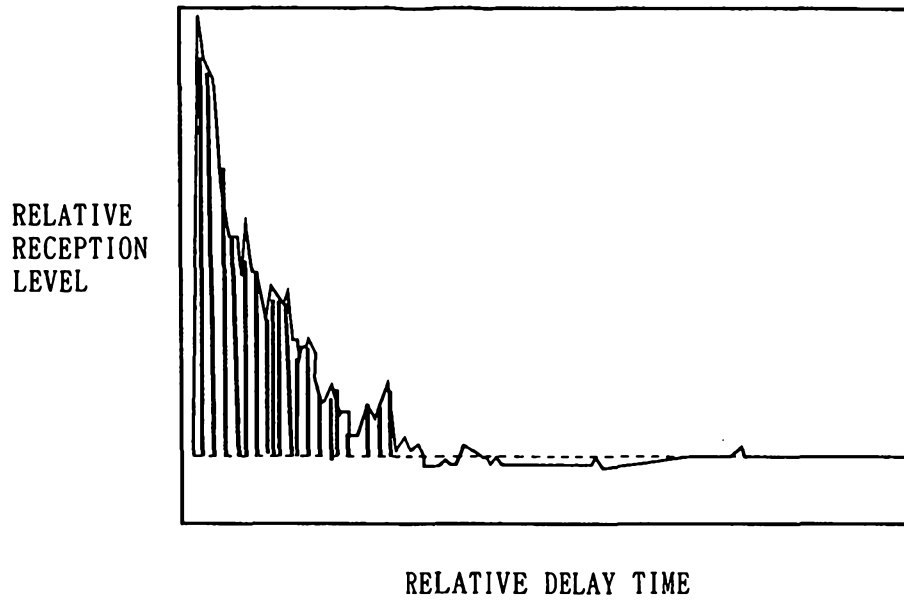


FIG. 18B

