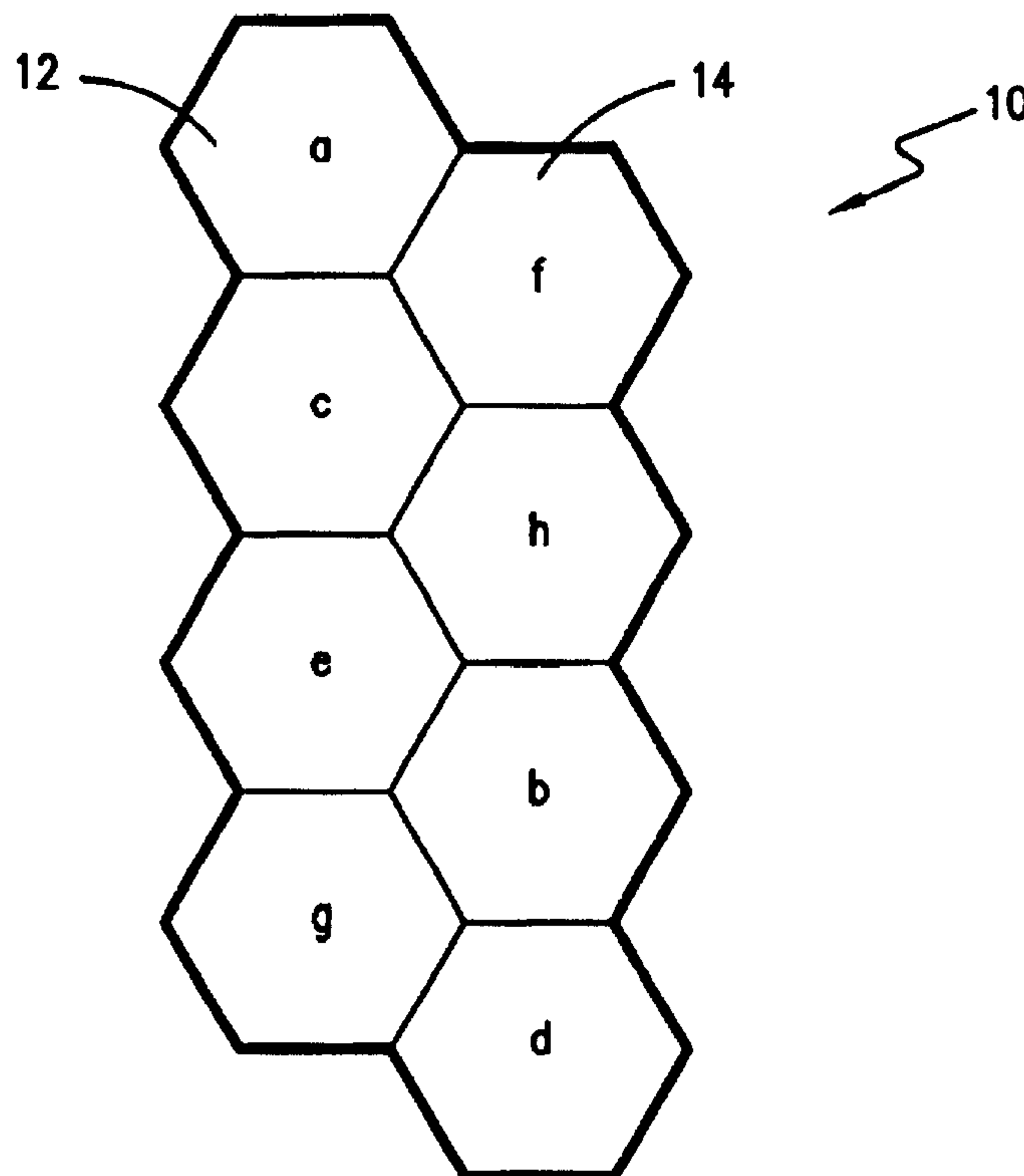




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 (54) Title: FREQUENCY ASSIGNING METHOD FOR AN EIGHT CELL FREQUENCY RE-USE PLAN



(57) **Abrégé/Abstract:**

A cell cluster for use with a frequency re-use pattern is disclosed. The cell cluster comprises eight antenna sites arranged in first and second adjacent columns having four sites associated with the first column and four sites associated with the second column. Frequency groups are assigned to each of the antenna sites such that no adjacent channel interference exist between the antenna sites or between any similarly configured cell clusters associated with the cell cluster.

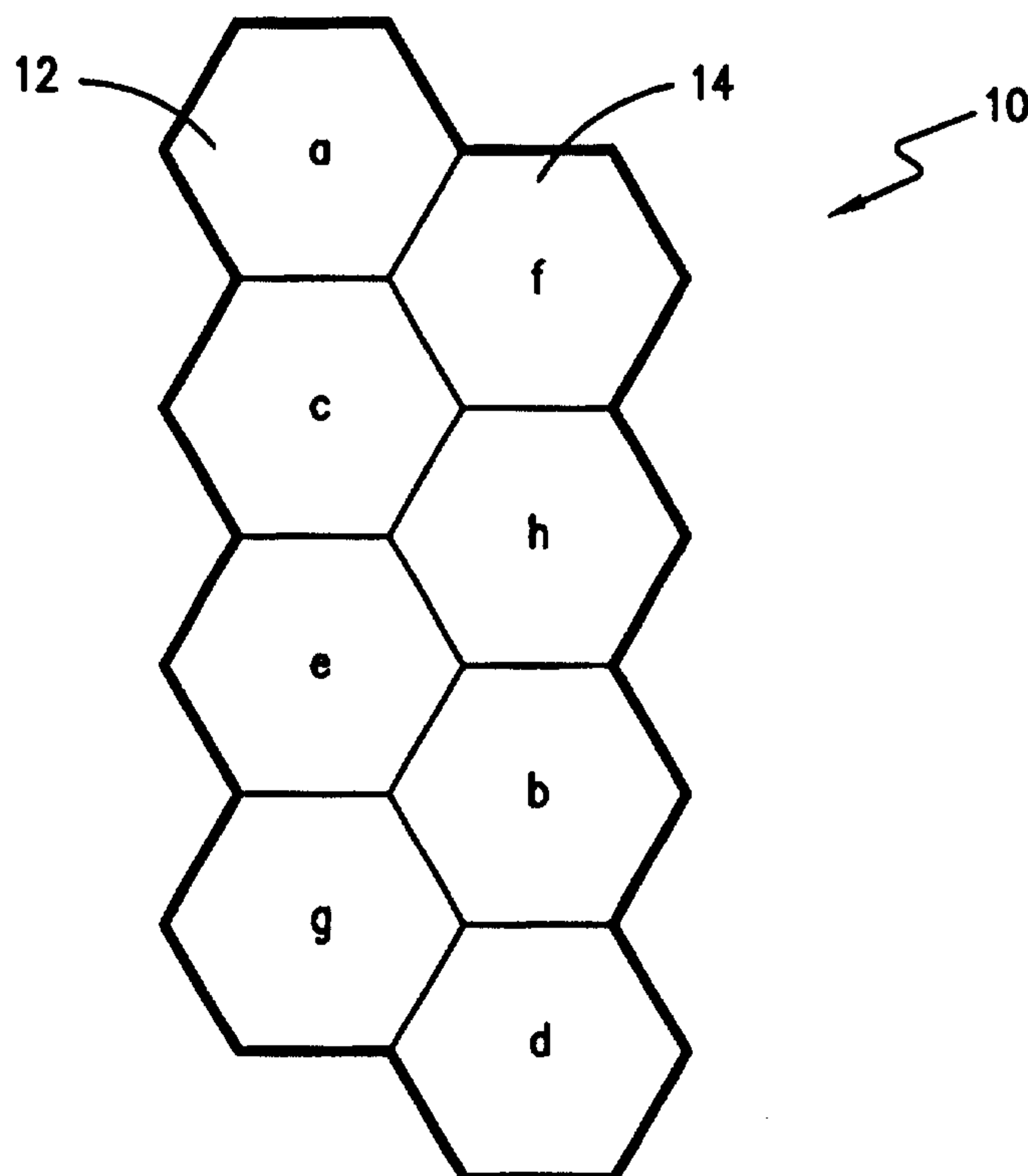
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<b>(21) International Application Number:</b> PCT/US97/24296 <b>(22) International Filing Date:</b> 23 December 1997 (23.12.97) <b>(30) Priority Data:</b> 08/777,818                      31 December 1996 (31.12.96)      US <b>(71) Applicant:</b> ERICSSON INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US). <b>(72) Inventor:</b> MAO, Tom; 3929 Bexhill, Plano, TX 75025 (US). <b>(74) Agents:</b> BACON, Jeffery, E. et al.; Jenkins & Gilchrist, P.C., Suite 3200, 1445 Ross Avenue, Dallas, TX 75202 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, 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, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>  <b>(88) Date of publication of the international search report:</b> 23 December 1998 (23.12.98)

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A cell cluster for use with a frequency re-use pattern is disclosed. The cell cluster comprises eight antenna sites arranged in first and second adjacent columns having four sites associated with the first column and four sites associated with the second column. Frequency groups are assigned to each of the antenna sites such that no adjacent channel interference exist between the antenna sites or between any similarly configured cell clusters associated with the cell cluster.



**FREQUENCY ASSIGNING METHOD FOR  
AN EIGHT CELL FREQUENCY RE-USE PLAN**

BACKGROUND OF THE INVENTION

5           Technical Field of the Invention

The present invention relates to frequency re-use structures, and more particularly, to a frequency re-use structure, including eight cell clusters that substantially eliminates adjacent channel interference.

10           Description of Related Art

Frequency re-use patterns are cell-based structures by which the frequency channels within a cellular radio system are assigned. The most basic unit of any frequency re-use pattern is a cell. To each cell in a frequency re-use pattern are assigned a number of frequency channels. A group of cells associated together are referred to as a cluster. A cluster contains all of the frequency channels available to a particular cellular radio system. Groups of clusters are then used to provide a cellular coverage over a specific area for a cellular system. The association of all frequency channels within a single cluster enables the re-use of the frequency channels throughout the cellular system.

25           The clusters are structured and frequencies within the clusters assigned to increase the re-use distance and limit co-channel and adjacent channel interferences. Co-channel interference consists of interference caused between uses of the same frequency within two different cell clusters. Adjacent channel interference is caused by interference between adjacent frequency channels within the same cluster or within two different clusters. In order to reduce interference within the cellular system, both co-channel and adjacent channel interference must be minimized. Competing with these requirements is the need for increased system capacity. In general, the smaller number of cells used in a cluster within a mobile radio

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system, the higher the capacity of the system and the lower the co-channel re-use distance. A smaller co-channel re-use distance, of course, increases co-channel interference.

5           Frequency re-use patterns have been extensively studied in the cellular industry. Frequency re-use patterns minimizing adjacent channel interference have been proposed for cell clusters of greater than nine cells in size. However, claims have been made in existing  
10 studies, that adjacent channel interference may not be avoided when the number of cells in a cluster is less than nine. Existing frequency re-use patterns using less than nine cells, all suffer from the problem of adjacent channel interference. A system which enabled the use of  
15 clusters including less than nine cells with enhance the channel capacity, provided good co-channel interference characteristics and substantially eliminated adjacent channel interference problems would greatly benefit users and providers of cellular telephone services.

20

#### SUMMARY OF THE INVENTION

The present invention overcomes the foregoing and other problems with an improved cell cluster for use with a frequency re-use pattern. In a first embodiment, the  
25 cell cluster consists of eight cells arranged in first and second adjacent horizontal, vertical, or diagonal columns. Both columns include four cells and form a cluster in a rectangular configuration. Eight different frequency groups are assigned to each of the eight cells. Each  
30 frequency group consists of non-adjacent frequency channels, and the assignment of the eight frequency groups is such that there are no adjacent channels between any of the eight cells, nor are there adjacent channels with any similarly configured cell clusters associated with the  
35 eight cell cluster.

The above-described cell cluster works with an omnidirectional configuration wherein eight omnidirectional

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antennas are located at the center of each of the eight cells or with a center excited, sectorized antenna configuration wherein each of the eight frequency groups further includes three sub-groups. Each of the sub-groups associated with a frequency group do not include any adjacent frequency channels.

In a second embodiment, eight antenna sites are arranged in first and second adjacent columns or rows wherein each column or row includes four antenna sites. Each antenna site has three cells associated therewith and each cell employs three directional antennas and forms a twenty-four cell cluster. Located at each antenna site are sectorized three-sector antennas transmitting into the three cells associated with the antenna site. Eight frequency groups consisting of three sub-groups each and having no adjacent frequency channels are assigned to each of the antenna sites with each cell receiving a sub-group such that there are no adjacent frequency channels between any of the twenty-four cells associated with the eight antenna sites and no adjacent channels with any similarly configured cell cluster associated with the cell cluster.

#### BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is made to the following detailed description taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a diagram of the eight cell cluster using the omni-directional antenna configuration that provides no adjacent channel interference within the same cluster;

FIGURE 2 is an illustration of the frequency re-use plan for an N=8 cell cluster using the omni-directional antenna configuration that provides no adjacent channel interference between two different clusters;

FIGURE 3 is an illustration of a center-excited sectorized antenna configuration within an eight-cell cluster based upon, wherein each of the eight frequency

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groups further includes three separate sub-groups that provide no adjacent channel interference within the same cluster;

5 FIGURE 4 is an illustration of a frequency re-use pattern for an N=8 cell cluster using the center-excited sectorized antenna configuration that provides no adjacent channel interference between two different clusters;

FIGURE 5 is an illustration of a clover-leaf configuration using a cluster structure; and

10 FIGURE 6 is an illustration of the frequency re-use pattern for the clover-leaf configuration.

#### DETAILED DESCRIPTION OF THE INVENTION

Referring now to the Drawings, and more particularly, to FIGURE 1, there is illustrated the basic cluster for an N=8, omni-directional pattern, where N equals the frequency re-use number (the number of cells) in a cluster. The pattern is a rectangular shaped cell cluster 10 having four vertically aligned cells 12 immediately adjacent to another four vertically aligned cells 14 forming a 4 by 2 array of cells. This pattern and the frequency assignment scheme associated therewith, which will be more fully discussed in a moment, provide all the basic properties of a conventional re-use pattern, such as, repeatability, splitability, and applicability. Alternatively, the two columns 12, 14 of four cells may be arranged horizontally or diagonally rather than vertically.

The proposed N=8 frequency plan for an omni-directional antenna site as shown in FIGURE 1, is based on dividing all the available frequency channels into eight or multiples of eight frequency groups with approximately  $t/8$  channels per group, where  $t$  is the total number of available channels in the spectral band designated by the authority. Table 1 shows the channel assignments for an omni-directional antenna systems.

#### Frequency Channel Group

	a	b	c	d	e	f	g	h
<b>Channel</b>	1	2	3	4	5	6	7	8
<b>Number</b>	9	10	11	12	13	14	15	16
5	17	18	19	20	21	22	23	24

**Table 1**

As can be seen from Table 1, each of the frequency channels are assigned sequentially to each frequency channel group. A frequency channel group is then associated with each cell in a manner that eliminates adjacent frequency channels within the cluster and with adjacent clusters. These same frequencies after being assigned to a first cluster may then be re-used by other clusters according to the same assignment configuration in order to provide cellular coverage over a specific area.

The basic eight cell cluster uses an odd and even channel distribution scheme wherein the odd and even channels in the basic cluster form two vectors, A and B, as follows:

$$A = \begin{bmatrix} a \\ c \\ e \\ g \end{bmatrix} \quad B = \begin{bmatrix} f \\ h \\ b \\ d \end{bmatrix}$$

or

$$A = \begin{bmatrix} g \\ e \\ c \\ a \end{bmatrix} \quad B = \begin{bmatrix} d \\ b \\ h \\ f \end{bmatrix}$$

Vector A contains four frequency channel groups and Vector B also contains four frequency channel groups. Vector A is assigned to one column and Vector B is assigned to the other column. As can be seen, the

adjacent frequency channel groups are offset by at least one other frequency channel group either vertically or horizontally to eliminate the possibility of adjacent frequency channels within the cluster. Thus, adjacent frequency channel groups are each separated from each other by at least one other group.

The eight cell cluster is associated in a frequency re-use pattern as shown in FIGURE 2. With each cluster, the assigned channel frequencies for the cellular system are re-used. Due to the basic cluster shape of the N=8, omni-directional antenna site, it is only possible to expand the basic cluster in the vertical and horizontal directions. This provides a frequency group repeating sequence for the structure of FIGURE 2, that limits co-channel interference and eliminates adjacent channel interference as shown below in Table 2.

20	a	f	a	f	a	f
	c	h	c	h	c	h
	e	b	e	b	e	b
	g	d	g	d	g	d
	a	f	a	f	a	f
	c	h	c	h	c	h
25	e	b	e	b	e	b
	g	d	g	d	g	d

**Table 2**

As can be seen from Table 2, the co-channels in the horizontal direction are always one cell apart (with a center-to-center distance of 3R; where R is the cell radius) from the serving cell on each side. The co-channels in the vertical direction are always three cells apart (with a center-to-center distance of 8R), and the co-channels on the diagonal direction are separated by center-to-center distance of 3R in the horizontal direction and 8R in the vertical direction. This provides co-channel interference performance that is on par with

or slightly better than a normal seven cell cluster configuration.

5 The most important feature of this N=8 omni-directional antenna pattern is that it is free of adjacent channel interference within the cluster as well as between two different clusters. Thus, while this particular frequency re-use pattern provides less traffic capacity than a normal N=7 system, the freedom from adjacent channel interference greatly reduces the total interference within a mobile telecommunications system. This is due to the fact that in a mobile telecommunications system, interference consists of the noise plus adjacent channel interference, plus co-channel interference. Since the noise is limited in a mobile telecommunications environment, this means either the adjacent channel or co-channel interference or both must be reduced. Since this configuration provides approximately equal or slightly better co-channel interference, the elimination of adjacent channel interference improves system performance.

20 The frequency re-use pattern of the present invention may also be used with a sectorized antenna cell configuration. For a three sector directional antenna site, this configuration would use 24 frequency groups in an eight site re-use pattern having approximately t/24 channels per group. This type of channel assignment is illustrated in Table 3.

30

		Frequency Channel Group																							
		a1	b1	c1	d1	e1	f1	g1	h1	a2	b2	c2	d2	e2	f2	g2	h2	a3	b3	c3	d3	e3	f3	g3	
h3	Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
24	Number	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
35	48																								

Table 3

40 As can be seen, each frequency group (a, b, c, d, e, f, g, h) is divided into three separate sub-groups (a1, a2, a3; b1, b2, b3; c1, c2, c3; etc.), and frequency

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assignments from sub-frequency groups are made to each sector. The sectorized center excited cell and frequency plans are direct extensions of the omni-directional antenna configuration. The frequency group assignment method is the same as that of omni-directional antenna pattern except that each frequency group in the sectorized plan is divided into three sub-groups at each location. For example, frequency group a in the omni-directional plan now is divided into frequency groups a1, a2, and a3; frequency group b is divided into frequency groups b1, b2, b3; etc. Frequency groups a1, a2, and a3 are then assigned to the three sectors of a sectorized site. Two different sectorized cell patterns are available, namely the center-excited and clover-leaf cell patterns.

FIGURE 3, illustrates a cluster of center-excited three sector directional antenna patterns. Each site contains a single antenna site 18 with three sectors 20 having antenna pointing azimuth separated by  $120^\circ$ . It should be understood that while FIGURE 3 is described with respect to a three sector configuration other multi-sector configuration may be used. Each sector 20 is approximated by the shape of a rhombi. Each sector 20 can use, for example,  $60^\circ$ ,  $90^\circ$  or  $120^\circ$  transmit antenna and two corresponding diversity receiver antennas with the same pointing azimuth. The center-excited three sector patterns splits the hexagon representing the site into three rhombi and assigns a frequency group having three sub-groups to each site. The three sub-groups of a channel frequency group are assigned to each sector 20 of the site as is illustrated in FIGURE 3.

Referring now to FIGURE 4, as with the omni-directional antenna configuration, the cluster shape of the three sector center excited configuration only permits expansion in the vertical and horizontal directions. This configuration provides co-channels separated in the horizontal direction by a distance of  $3R$  (center-to-center) from the serving cell on both sides. Co-channels

in the vertical direction are separated by a distance of  $4\sqrt{3}R$  (center-to-center). Co-channels in the diagonal direction are separated by  $3R$  in the horizontal direction and  $4\sqrt{3}R$  in the vertical direction. There are eight co-channel interferers on the first co-channel tier. Again, as in the omni-directional antenna plan there are no adjacent channels assigned to adjacent cells, sectors, or clusters, and thus, no adjacent channel interference.

Referring now to FIGURE 5, there is illustrated the cluster of clover-leaf configuration for a sectorized three sector directional antenna pattern. The site geometry includes three cells at each antenna site wherein the antenna pointing azimuth of each cell is separated by  $120^\circ$  and the cells are arranged in a clover-leaf fashion. Each cell is approximately the shape of a hexagon and uses, for example,  $60^\circ$ ,  $90^\circ$  or  $120^\circ$  transmit antenna and two corresponding diversity receiver antennas along each antenna pointing azimuth.

The clover-leaf pattern consists of three cells at the center of which is an antenna location. Each antenna site is assigned a frequency group including three sub-groups in the same manner as that discussed with respect to the center excited configuration. Thus, each site would include an assignment of frequency  $a_1, a_2, a_3; b_1, b_2, b_3; \text{etc.}$ , as shown. The relationships for the assigned frequency channels of the eight antenna sites utilized by the clover-leaf pattern is the same as that for the frequency channel assignment relationship with respect to a omni-directional or center-excited sectorized configuration. The antenna sites are arranged in a substantially rectangular or parallelogram configuration. Rather than being located within the center of a single cell, the antenna site is located at the intersection of three adjacent cells.

The cluster re-use pattern for a clover-leaf configuration is illustrated in FIGURE 6. Due to the

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basic cluster-shape of the sectorized directional 8/24 plan, it is only possible to expand the basic cluster vertically and horizontally. As can be seen in FIGURE 6, the co-channels in the horizontal direction are always separated by a distance of  $6R$  (center-to-center) from the serving cell on both sides and  $12R$  (center-to-center) in the vertical direction. The co-channels in the diagonal direction are  $6R$  apart in the horizontal direction and  $12R$  in the vertical direction. There are a total of eight co-channel interferers on the first co-channel tier. Again, there are no adjacent channels assigned to adjacent cells within the cluster and adjacent channel interference does not occur between clusters.

Because of the antenna directivity, the co-channels located on the vertical and diagonal have more impact on the co-channel interference, while the channels located on the horizontal have less impact with respect to the serving cell. However, the co-channels located on the vertical have more distance separation that offsets the impact of the co-channel interference resulting from the antenna directivity. Although preferred embodiments of the method and apparatus of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it is understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the invention as set forth and defined by the following claims.

30

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A cell cluster for use with a frequency re-use pattern, wherein the cell cluster comprises:
  - eight cells arranged in first and second adjacent columns, wherein the first column includes four cells and the second column includes four cells; and
  - eight frequency groups assigned to the eight cells such that there are no adjacent channels between any of the cells once each of the frequency groups are assigned to a cell.
2. The cell cluster of claim 1 wherein location of the eight cells with other similarly arranged clusters of eight cells creates no adjacent channels between cells of any adjacent clusters.
3. The cell cluster of claim 2 wherein the horizontal distance between co-channels is  $3R$ .
4. The cell cluster of claim 2 wherein the vertical distance between co-channels and cells is  $8R$ .
5. The cell cluster of claim 2 wherein the diagonal distance between co-channels is  $3R$  in the horizontal and  $8R$  in the vertical.
6. The cell cluster of claim 1 further including omnidirectional antenna sites associated with each of the eight cells.
7. The cell cluster of claim 1 further including sectorized antenna sites located at the center of each of the eight cells.
8. The cell cluster of claim 7 wherein the horizontal distance between co-channels is  $3R$ .

9. The cell cluster of claim 7 wherein the vertical distance between co-channels is  $4\sqrt{3}R$ .
10. The cell cluster of claim 7 wherein the diagonal distance between co-channels is  $3R$  in the horizontal and  $4\sqrt{3}R$  in the vertical.
11. The cell cluster of claim 1 wherein the eight frequency groups are designated a, b, c, d, e, f, g, and h, respectively, and all frequency channels are assigned from frequency group a to frequency group h in a repeating and sequential fashion.
12. The cell cluster of claim 11 wherein no two adjacent frequency groups are assigned to physically adjacent cells of the cell cluster.
13. A frequency re-use system comprising:
  - eight antenna sites associated together in a repeating pattern; and
  - eight frequency groups assigned to the antenna sites such that no two antenna sites have adjacent frequency channels between them once each of the frequency groups are assigned.
14. The frequency re-use plan of claim 13 wherein each antenna site comprises a sectorized antenna sites transceiving signals in three cells arranged in a clover-leaf fashion.
15. The frequency re-use plan of claim 13 wherein the horizontal distance between co-channels is  $6R$ .
16. The cell cluster of claim 13 wherein the vertical distance between co-channels is  $12R$ .
17. The cell cluster of claim 13 wherein the diagonal distance between co-channels is  $6R$  in the horizontal and  $12R$  in the vertical.

18. A cell cluster for use with a frequency re-use plan, the cell cluster comprising:  
eight cells arranged in first and second adjacent vertical columns wherein the first column includes four cells and the second column includes four cells;  
eight frequency groups consisting of non-adjacent frequency channels in each frequency group, wherein each of the eight frequency groups are assigned to one of the eight cells such that there are no adjacent channels between any of the cells with the eight cells and any similarly configured cell cluster associated with the cell cluster.
19. The cell cluster of claim 18 further including omnidirectional antenna sites associated with each of the eight cells.
20. The cell cluster of claim 18 further including sectorized antenna sites located at the center of each of the eight cells.
21. The cell cluster of claim 18 wherein the eight frequency groups are designated a, b, c, d, e, f, g, and h, respectively, and all frequency channels are assigned from frequency group a to frequency group h in a repeating and sequential fashion.
22. The cell cluster of claim 18 wherein the frequency groups comprise three sub-groups having non-adjacent frequency channels assigned thereto.

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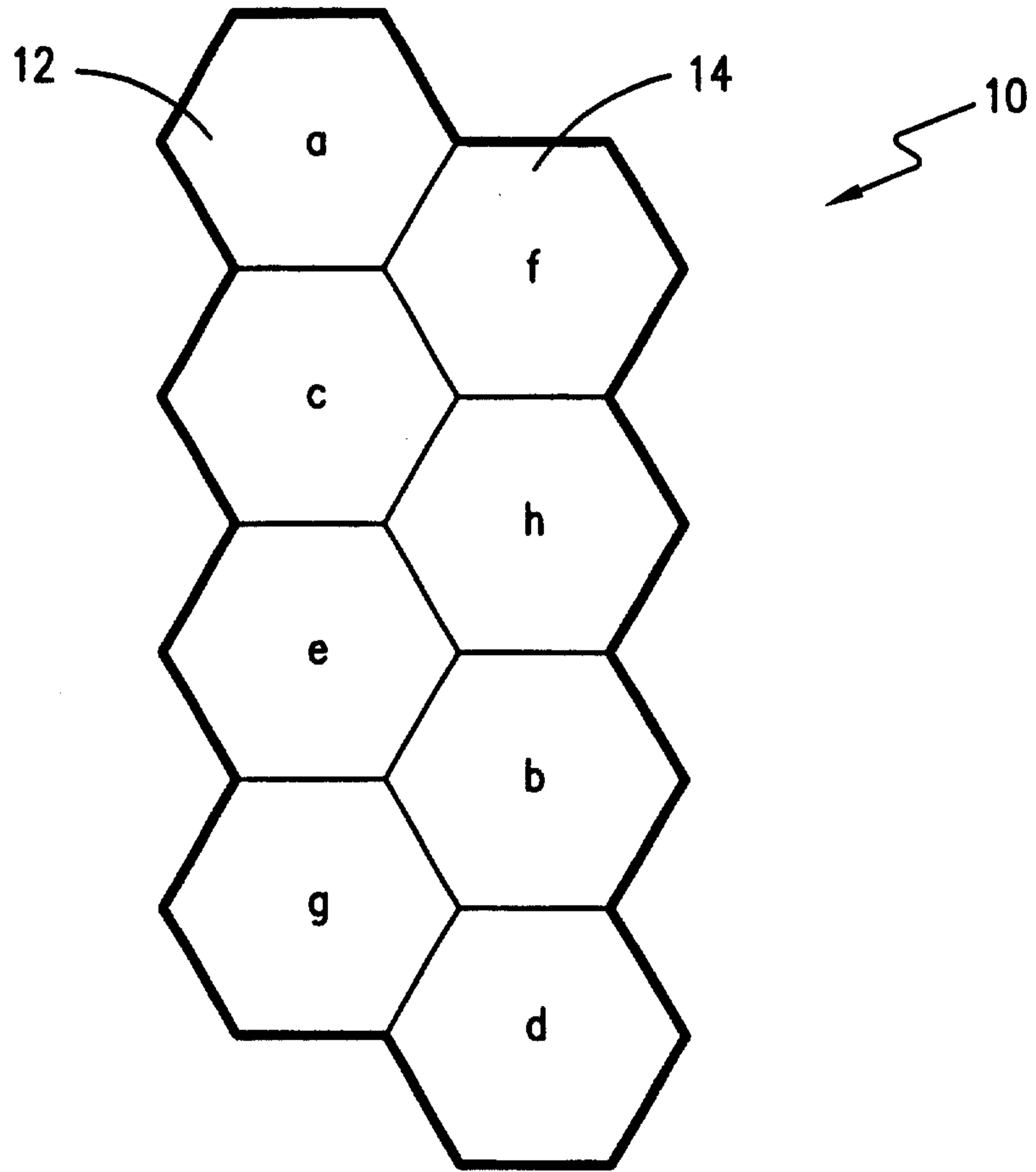


FIG. 1

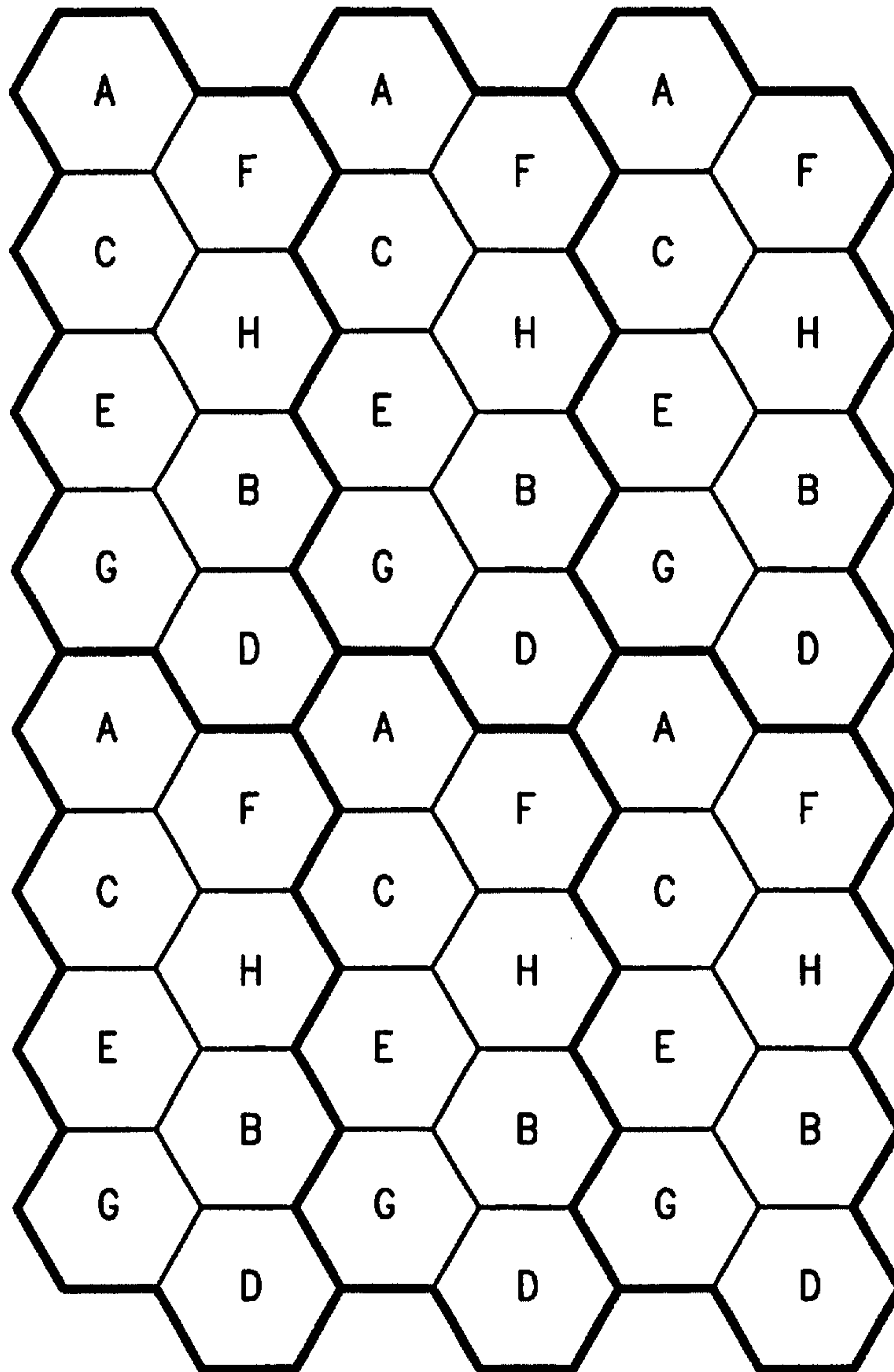


FIG. 2

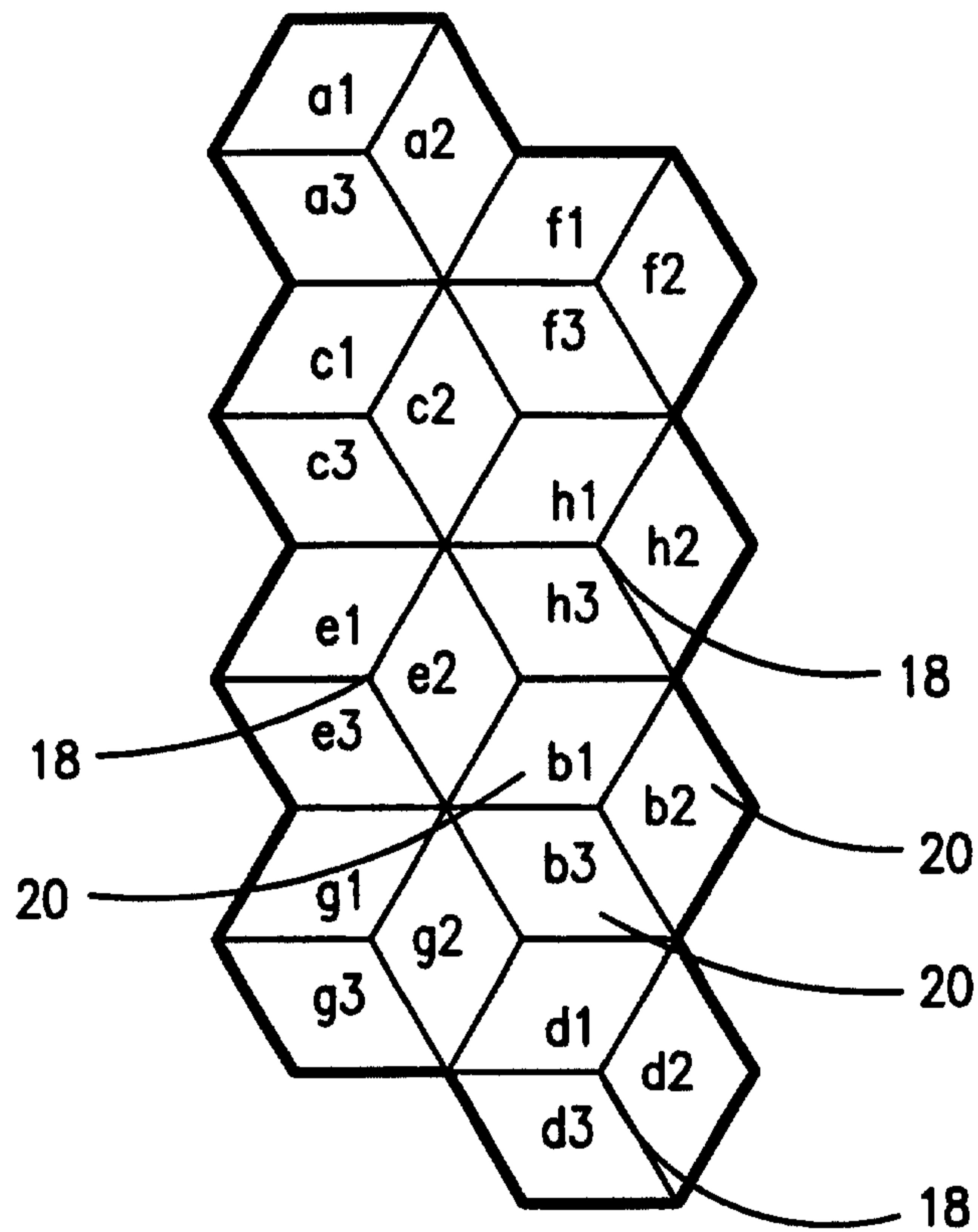


FIG. 3

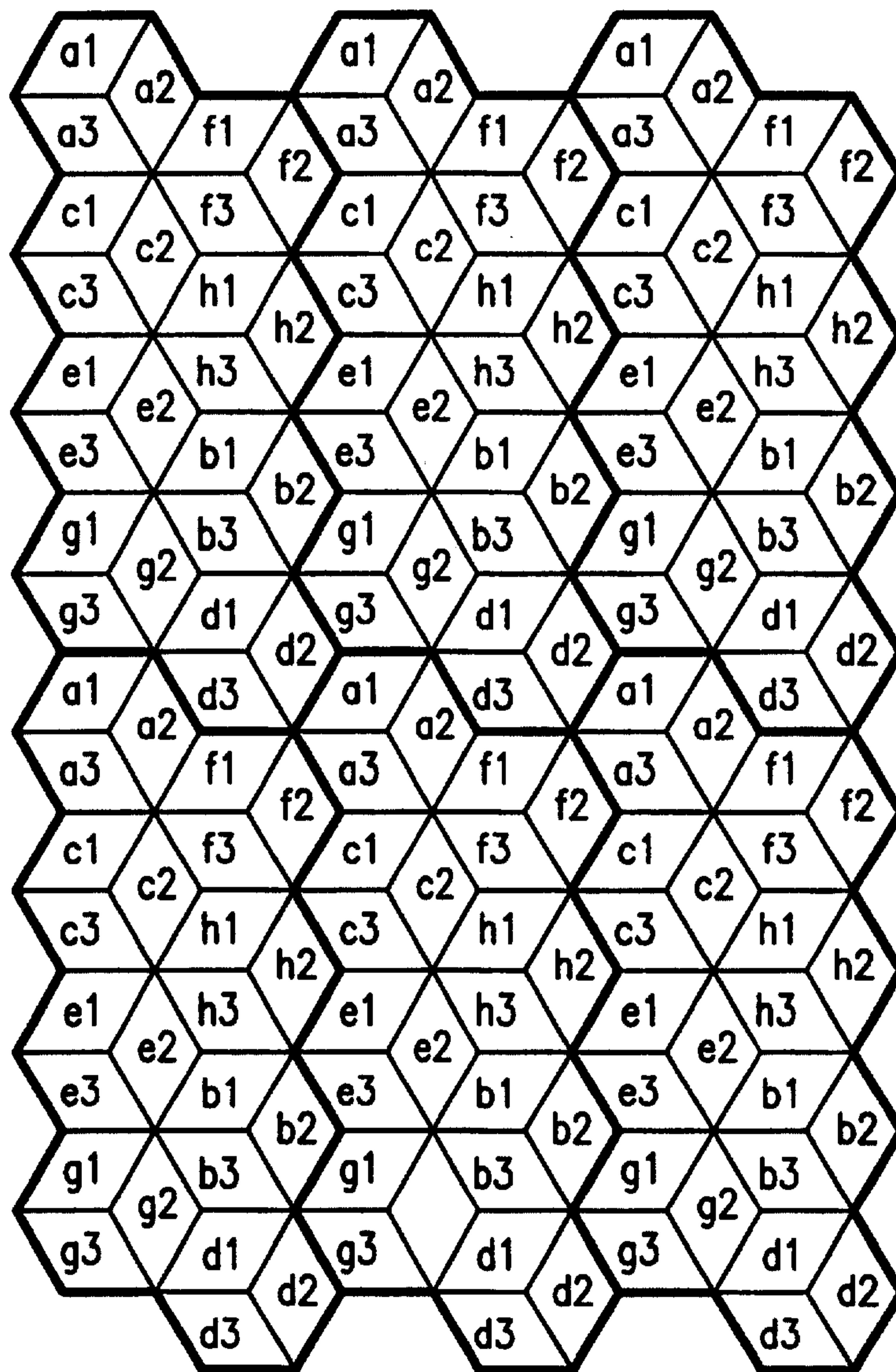
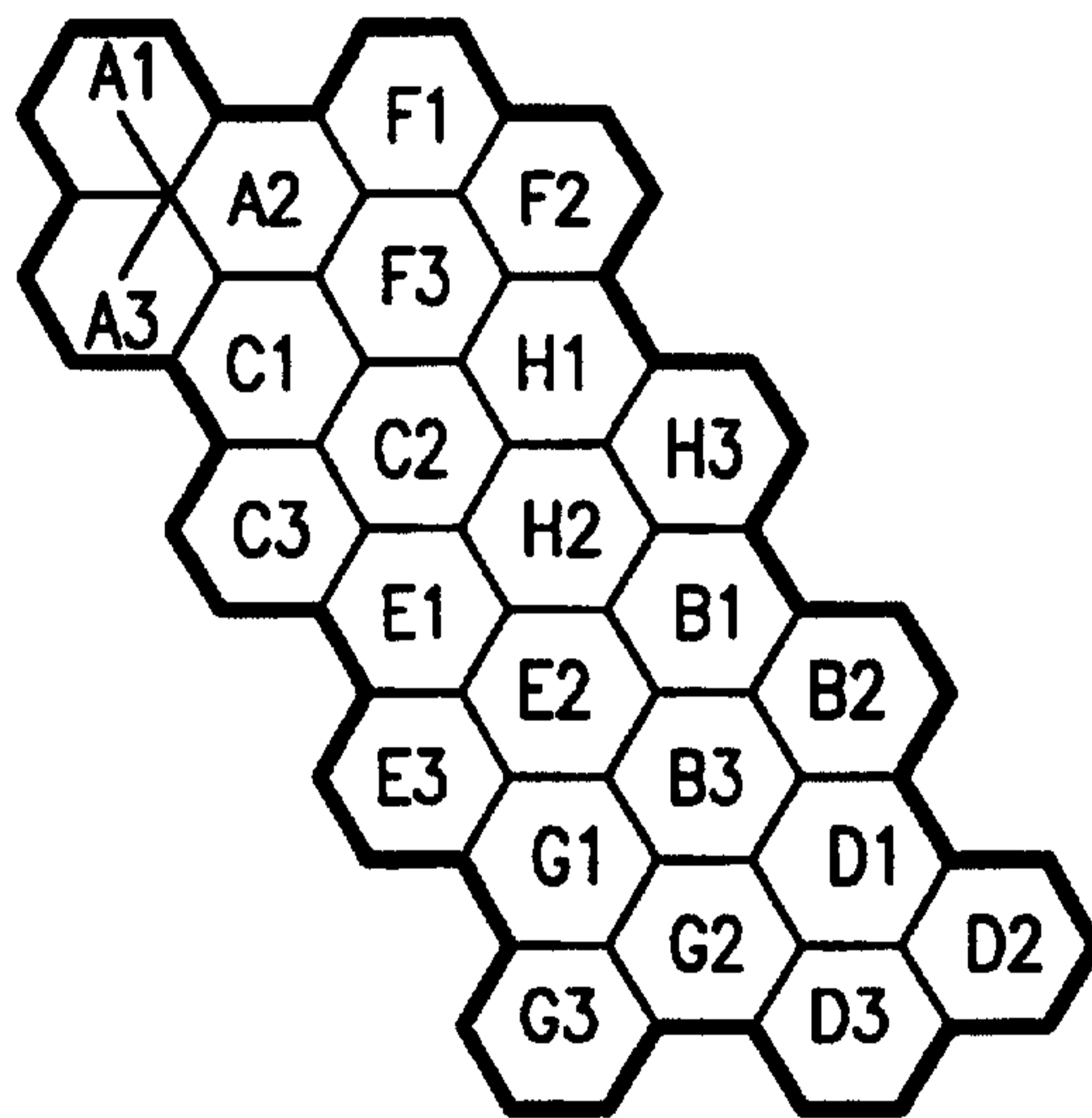


FIG. 4



*FIG. 5*

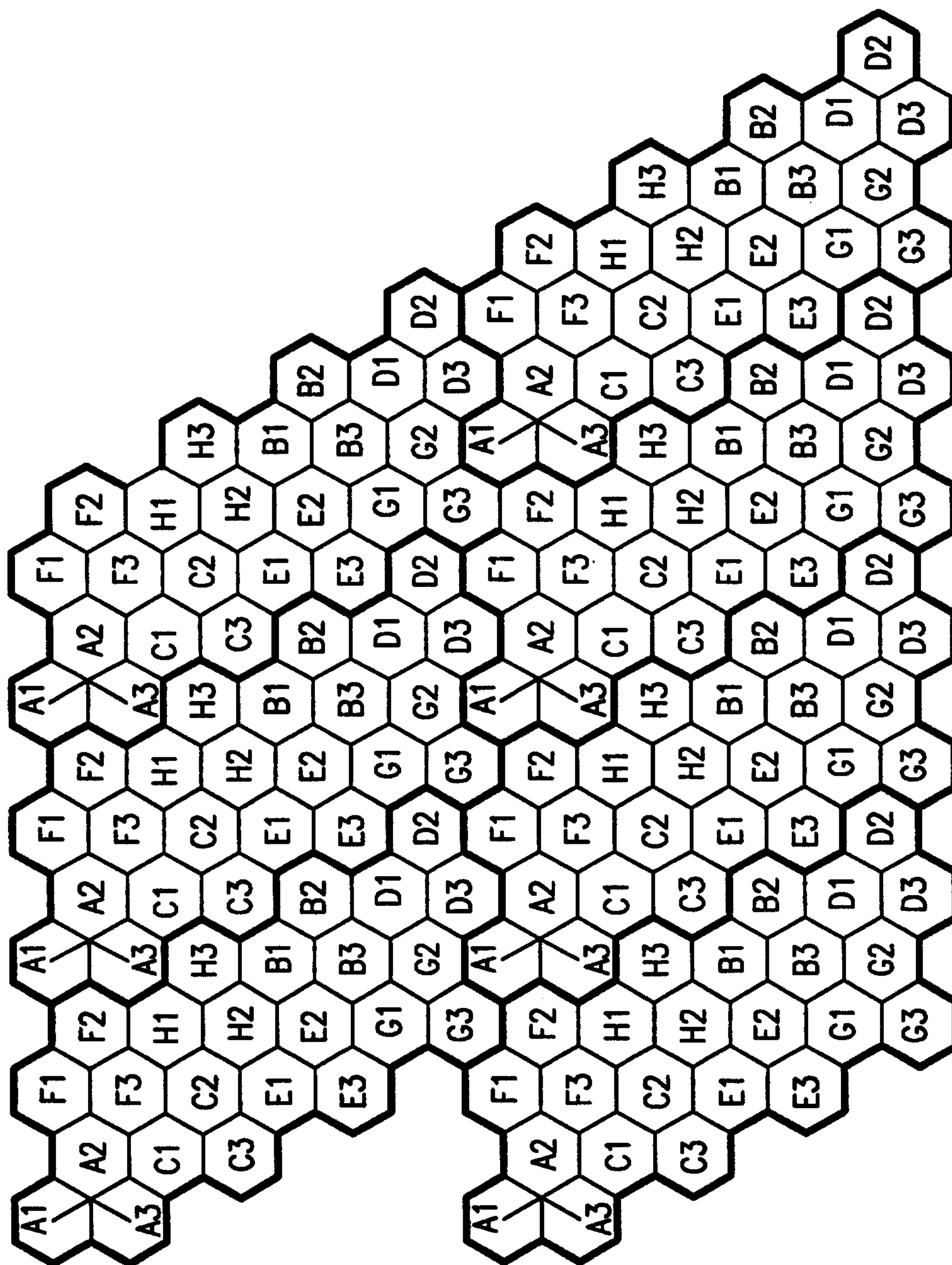


FIG. 6

