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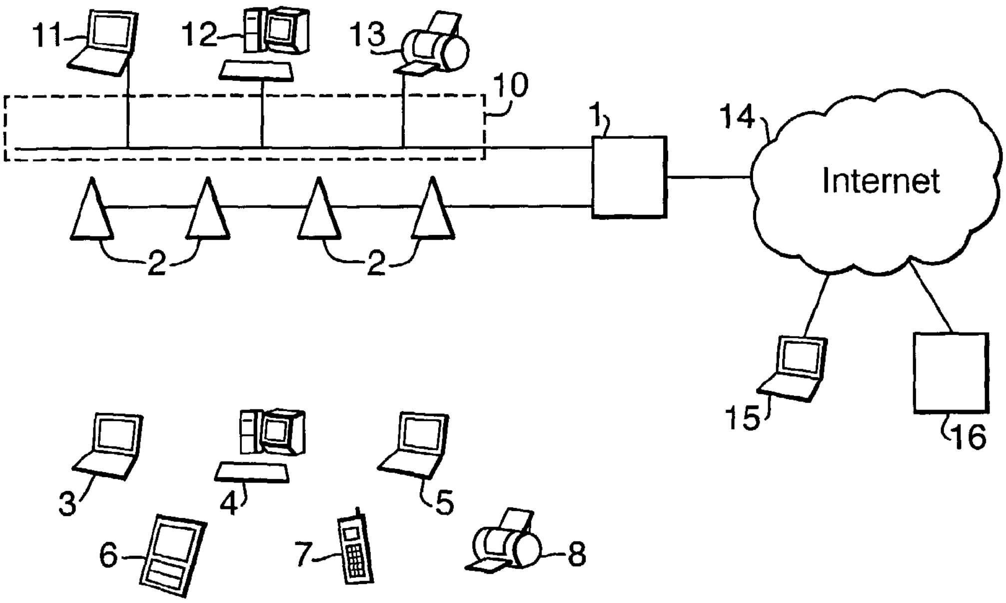

(57) Abstract: The present invention provides a method of determining a network configuration, and a network which is capable of determining its own configuration. The network configuration is determined by monitoring selected information regarding the wireless connections established by transceivers in the network and then using this selected information to determine the network configuration. The selected information usually includes an indication of the signal strenght of the transceivers involved in the connection, and preferably both the received and transmitted signal strenght. The signal strenght of the connection provides an indication of the physical separation of the transceivers and by considering the signals strenght of a specific network element connected to different transceivers in the network, the position of the network element can be determined.

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NETWORK CONFIGURATION METHOD AND SYSTEM

Field of the Invention

The present invention relates to a network for providing wireless connectivity to wireless enabled communications devices and to a method of determining the consideration of such a network.

Background to the Invention

Currently, the majority of computer networks utilize some form of wiring for interconnecting the computers on the network. These systems suffer from the major drawbacks that wiring has to be installed within the building to enable the network to be fitted, and additionally, should a fault with the wiring develop, this can lead to the need for wiring to be replaced. In addition to this, the wiring can cause problems due to interference with other electrical equipment within the building, as well as only having a limited bandwidth. Furthermore, different networks require different wiring standards which further leads to the complexity of installing networks in buildings.

Wireless types of networks are now becoming more wide spread. Wireless communication can be broken down into one of three main categories, radio, cellular and local. Radio communications are used for mainly long distance work, and cellular communications are used for mobile phones and the like. At present, the cellular system can also be used to provide limited Internet access using WAP (Wireless Application Protocol) phones. Internet access is also possible via a cellular phone, a GSM modem and a PC/PDA.

In addition to this, the local communication standards are also provided for short-range radio communication. These systems have been used within the production of wireless networks.

One such short-range radio communication radio system is Bluetooth which can be used to provide customer premises wireless links for voice, data and multi-media applications.

A Bluetooth Radio Frequency (RF) system is a Fast Frequency Hopping Spread Spectrum (FFHSS) system in which packets are transmitted in regular time slots on frequencies defined by a pseudo random sequence. A Frequency Hopping system provides Bluetooth with resilience against interference. Interference may come from a variety of sources including microwave ovens and other communication systems operating in this unlicensed radio band which can be used freely around the world. The system uses 1MHz frequency hopping steps to switch among 79 frequencies in the 2.4GHz Industrial, Scientific and Medical (ISM) band at 1600 hops per second with each channel using a different hopping sequence.

The Bluetooth baseband architecture includes a Radio Frequency transceiver (RF), a Link Controller (LC) and a Link Manager (LM) implementing the Link Manager Protocol (LMP).

Bluetooth version 1.1 supports asymmetric data rates of up to 721Kbits per second and 57.6Kbits per second and symmetric data rates of up to 432.5Kbits per second. Data transfers may be over synchronous connections, Bluetooth supports up to three pairs of symmetric synchronous voice channels of 64Kbits per second each.

Bluetooth connections operate in something called a piconet in which several nodes accessing the same channel via a common hopping sequence are connected in a point to multi-point network. The central node of a piconet is called a master that has up to seven active slaves connected to it in a star topology. The bandwidth available within a single piconet is limited by the master, which schedules time to communicate with its various slaves. In addition to the active slaves, devices can be connected to the master in a low power state known as park mode, these parked slaves cannot be active on the channel but remain synchronised to the master and addressable. Having some devices connected in park mode allows more than seven slaves be attached to a master concurrently. The parked slaves access the channel by becoming active slaves, this is regulated by the master.

Multiple piconets with overlapping coverage may co-operate to form a scatternet in which some devices participate in more that one piconet on a time division multiplex basis. These and any other piconets are not time or frequency synchronised, each piconet maintains is own independent master clock and hopping sequence.

Summary of the Invention

In accordance with a first aspect of the present invention, we provide a network for providing wireless connectivity to wireless enabled communications devices, the network comprising:

a number of interconnected transceivers, each transceiver being capable of establishing wireless connections; and, a processor coupled to the transceivers, the processor being adapted to:

monitor wireless connections provided by at least some of the transceivers with other network elements;

determine selected information regarding the wireless connections; and,

determine a network configuration based on the selected information.

In accordance with a second aspect of the present invention, we provide a method of determining the configuration of a network, the network being formed from a number of interconnected transceivers, each transceiver being capable of establishing wireless connections with wireless enabled communications devices, the method comprising:

monitoring wireless connections provided by at least some of the transceivers; with other network elements;

determining selected information regarding the wireless connections; and,

determining the network configuration based on the selected information.

Accordingly, the present invention provides a method of determining a network configuration, and a network which is capable of determining its own configuration. The network configuration is determined by monitoring selected information regarding the wireless connections established by the transceivers of the network and then using this selected information to determine the network configuration.

The selected information usually includes an indication of the signal strength of the respective connection.

In this case the processor is generally adapted to determine the relative physical separation of the network element and the respective transceiver in accordance with the determined signal strength. This is possible because the signal strength will reduce as the separation of the transceiver and the respective network element increases. Accordingly, the present invention utilises this reduction in signal strength to allow an approximate physical separation between the two devices to be determined.

Preferably, the indication of the signal strength of the respective connection between a first device and second device includes both the transmitted signal strength at the first device and the received signal at the second device.

Alternatively, or additionally, if the transceivers include a directional antenna it is possible for the selected information to include an indication of connection direction. In this case, the processor is adapted to determine the direction of the network element relative to the respective transceiver.

It will be appreciated from this that by considering the signals obtained from a specific network element via connections from different transceivers, the position of the network elements can be determined. This can be achieved using simple trigonometric procedures based on the estimated separation and direction obtained from a different transceiver.

In one implementation the other network elements include other ones of the transceivers. Accordingly, this allows the network configuration to represent at least the relative physical locations of the transceivers. Accordingly, this system provides a technique by which the network is able to determine the position of all the transceivers within the network, thereby allowing the network to map its own configuration. This is particularly advantageous as it allows a map of the network to be determined automatically without input from a third party, such as a network user.

Furthermore, the changes in the network configuration, such as the moving of a transceiver, are automatically reflected in an update of the network map. This ensures that the network users can always access an up-to-date map showing the network configuration. This in turn will have applications regarding locating physical faults on the network, and the like.

As the transceivers are not normally adapted to communicate with each other via the wireless connections, the processor is typically adapted to determine the signal strength of wireless connections between the transceivers by causing a transceiver to establish one or more temporary connections with one or more of the transceivers and then determine the selected information regarding the temporary connection.

As an alternative however it may be possible to determine the location of other communications devices and then use this information to derive the network configuration.

Of course it is additionally possible for the other network elements to include communications devices and for the network configuration to include an indication of the relative physical location of the communications devices.

In this situation, it is then possible for the processor to be adapted to monitor movement of the communication devices relative to the network in accordance with the network configuration.

Accordingly, the system can be used to track the movement of communications devices around the network as the network is being used. This can be utilised by the systems operator to help overcome traffic bottlenecks in the communications network as well as allowing thus communications devices within range of the network to be located.

The network usually includes a store for storing used information for finding relationships between users of the network and their respective communications devices. Accordingly, in this case the processor is further adapted to monitor the location of the users in accordance with a network configuration. Thus, this provides a technique by which users of the network can be easily located. In addition to this, by saving the network configuration in a store, it is possible to track the movement of the users round the network throughout the day. Again, this can be used to improve the efficiency of the network.

In addition to this, the processor is typically further adapted to control at least one building function in accordance with the relative physical location of the communications devices. This would typically include building functions such as heating, lighting, door locks and alarms.

Accordingly, it will be appreciated from this that the present invention can be used to automatically activate building functions when a user, or at least a communications device enters a room. Thus, for example a light can be activated as the user enters the room, or alternatively alarms can be deactivated.

This could be implemented in many different ways, such as for example by hard wiring controllers which control the building functions, to the processor. In this case, the processor would have to be programmed with the location of the devices. This can be avoided however, by having each building function controlled by a respective wireless enabled function controller, the function controllers being responsive to commands received from the processor via the wireless connections. This overcomes the need for providing a wired connection from the processor to the function controller.

However, in addition to this, because the function controllers can act as the other network elements, it is possible for the network configuration to represent at least a relative physical location of the function controllers. Accordingly, the processor can be further adapted to determine the relative location of the building functions in accordance with the network configuration.

In this case, not only does the network operate to determine its own configuration and the relative location of communications devices, but the network can also determine the location of various building functions such as lighting. This can be used to ensure that the lighting is activated when a communications device enters a specific region of the building which is within a predetermined distance of the respective function controller.

The network typically includes a number of interconnected network nodes, each node including at least one respective transceiver and a network server coupled to the network nodes, the network server including the processor. This is not essential to the present invention however, it will be appreciated that the network nodes can advantageously comprise Access Points and the network server, advantageously comprise an Access Server as defined within the specification.

Brief Description of the Drawings

Examples of the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a schematic diagram of a network which provides wireless connections in accordance with the present invention;

Figure 2 is a schematic diagram of the Access Server of Figure 1;

Figure 3 is a schematic diagram of the Access Point of Figure 1;

Figure 4 is a schematic diagram showing the functionality of the Access Server and the Access Points; and,

Figures 5A to 5E are schematic diagrams showing the relative physical location of the Access Points of Figure 4;

Figure 6 is a schematic diagram showing the manner in which the location of a communications device is obtained;

Figure 7 is a schematic diagram showing the use of a network map in a building;

Figure 8 is a schematic diagram showing the location of building function controllers; and,

Figure 9 is a schematic diagram showing the application of the present invention to directional antennas.

Detailed Description

Figure 1 shows a basic network arrangement which provides wireless connections in accordance with the present invention. As shown, the network includes a wireless Access Server 1 which is coupled to a number of local area Access Points 2. The Access Points 2 are designed to communicate with a number of Bluetooth enabled communications devices 3,4,5,6,7,8 using Bluetooth connection.

In this scenario, the Bluetooth communication devices 3,4,5,6,7,8 can include devices such as a personal computer, laptop or the like which is fitted with a Bluetooth adapter, a specialised Bluetooth laptop, a Bluetooth enabled phone or mobile phone, a WAP Internet phone, a Bluetooth enabled personal data assistant (PDA) or a Bluetooth headset which are capable of establishing voice calls via the Bluetooth connections with the Access Points.

In fact under normal circumstances, the Access Server and Access Points can communicate with any Bluetooth enabled device. These include not only PCs, PDAs, and laptops but any of the following that have a Bluetooth port; a truck, a refrigerator, a baggage trolley, a keyboard etc, although this is not relevant for the purpose of the present invention.

The Access Server 1 is also optionally connected to a local area network 10 having a number of end stations 11,12,13. In this example, this allows the Access Server to be integrated with currently existing local area networks within a building.

The Access Server 1 can also be connected to a remote communications network 14, which in this example is the Internet. This allows the communications devices coupled to the Access Server to communicate with remote users 15 or Access Servers of other remote sites 16.

Accordingly, the Access Points 2 allow voice calls to be made by and received by the Bluetooth communications devices 3,4,5,6,7,8 in turn allowing voice calls to be made using the LAN 10 and the Internet 14, via the Access Server 1. In this case, the Access Server operates as a call controller, as will be described in more detail below.

The Access Server is shown in more detail in Figure 2.

The Access Server includes an Internet interface 20, an Access Point interface 21, a LAN interface 22 and a PBX interface 23, all of which are interconnected via a bus 24. A microprocessor 25 and a memory 26 which are provided for processing and storing the operating software, are also coupled to the bus 24. An input/output device 27 is also provided.

The processor 25 is typically an x86 type processor operating a Linux type operating system such as Red Hat Linux. This is particularly advantageous as the Linux system is widely used as the operating system for a number of different software applications. Accordingly, the system can implement a wide variety of standard operating software for network servers and the like, as well as allowing third parties the opportunity to modify existing software and develop their own software. However, any suitable form of processing system may be used.

In addition to these features, it is also possible to include a number of Bluetooth radios 28, and a GPRS radio transceiver 29, both of which are coupled to the BUS 24.

A range of radios are supported, including standard and enhanced range devices.

Similarly, the Bluetooth design of the Access Server and the Access Point offers capabilities beyond the basic Bluetooth specification. These include advanced control of Bluetooth device state to improve throughput, and control of broadcast and multicast traffic streams to/from Bluetooth devices.

In this example, four different interfaces 20,21,22,23 are shown. However, it is not essential for the Access Server 1 to include all of these interfaces, depending on the particular configuration which is to be used, as will be explained in more detail below.

Thus, in order to enable Bluetooth voice calls to be made between the Bluetooth communication devices and remote third parties, all that is required is for the Access Server to include the Access Point interface 21, with appropriately connected Access Points 2, and one of the Internet interface 20, the LAN interface 22, or the PBX interface 23, coupled to an appropriate communications device. Thus, for example, the LAN interface 22 could be coupled to an Ethernet phone via the LAN 10. Further examples will be described in more detail below. Alternatively, the Access Point interface need not be used if the Bluetooth transceivers 28 are used instead. However, this will become clearer when various network configurations used by the Access Server are described in more detail below.

The Internet interface 20 is used primarily for providing an ISDN connection to an Internet service provider. However, the system can be reconfigured to use Ethernet, DSL or a POTS modem for Internet connectivity. Thus, this allows VoIP calls to be transferred via the Internet 14.

The Access Point interface 21 is effectively an Ethernet interface which is adapted to operate with the Access Points, as will be explained in more detail below.

The LAN interface 22 is normally configured to be an Ethernet interface. However, this can be adapted to provide token ring or other forms of communication as required. Accordingly the LAN 10 can comprise an Ethernet, Token Ring or other similar network.

In order to be able to handle different communications protocols, each of the interfaces 20,21,22 will include a processor and a memory. The processor operates software stored in the memory which is appropriate for handling the required communications protocol. Thus in the case of the LAN interface 21, the default protocol is Ethernet. However, if alternative protocols such as Token Ring or ATM are used, then the software is adapted to translate the format of the data as it is transferred through the respective interface.

An Access Point according to the present invention is shown in Figure 3. The Access Point includes an Access Server interface 30, for connecting the Access Point to the Access Server. The Access Server interface 30 is connected via a BUS 31 to a processor 32 and a memory 33. The BUS is also coupled to a number of Bluetooth transceivers 34 (only one shown) providing enhanced capabilities such as improved bandwidth and call density.

The processor 32 is typically a processor system that can include one or more processors, of the same or different types within the system. For example, the processor system could include, but is not be limited to, a RISC (Reduced Instruction Set Computer) processor and a DSP (Digital Signal Processor) processor.

In use, the Access Points are connected to the Access Point interface 21 using a daisy chain Ethernet connection. This is particularly advantageous as it allows a large number of Access Points 2 to be connected in series via a single wire to the Access Point interface 21. In this case, power can be supplied to the Access Points 2 either via the connection from the Access Server 1, or via separate power supplies (not shown) connected to each of the Access Points 2 as required.

As an alternative however, it is possible for the Access Points 2 to be coupled to the Access Server 1 via an Ethernet hub, or the like. This has the advantage that it allows a larger number of Access Points to be coupled to one Access Server, although it is not usually possible to power the Access Points using this technique.

In use, each Access Point 2 is able to communicate with a number of communications devices 3,4,5,6,7,8 which are in range of the respective Bluetooth radio 34. Any data received at the radio is transferred to the memory 33 for temporary storage. The processor 32 will determine from the data the intended destination. If this is another Bluetooth device within range of the Access Point, the data will be transferred via the radio 34 to the appropriate communications device 3,4,5,6,7,8. Other Access Server data will be transferred via the BUS 31 to the Access Server interface 30 and on to the Access Server 1.

Upon receipt of the data by the Access Server 1, the Access Point interface 21 will temporarily store the data in the memory whilst the processor determines the intended destination of the data. The processor may also operate to translate the format of the data, if this is necessary. The data is then routed by the Access Server to the intended destination on either the LAN 2, the Internet 14 or alternatively, to a PBX network, as will be described in more detail below.

The traffic from Bluetooth devices (arriving through an Access Point or the Access Server) can be sent to the LAN through a number of different mechanisms; one is routing, another uses a technique called Proxy ARP to reduce the configuration needed. These mechanisms are bi-directional and also connect traffic from the LAN to Bluetooth devices.

Similarly, data can be transferred from the Access Server, via the Access Point interface 21 to an Access Point 2. In this case, the Access Point 2 receives the data and transfers it into the memory 33. The processor 32 then uses the data to determine the intended destination communication device before routing the data appropriately.

Operation of the Access Server to determine the network configuration will now be described with reference to Figure 4, which show the functionality of the Access Server and the Access Points, and Figure 5 which shows the relative positioning of the Access Points.

As shown in Figure 4, the Access Server 1 includes a connection manager 50 which is coupled to the Internet interface 20, the LAN Interface 22 and the PBX Interface 23, as well as being coupled to a Bluetooth stack 51 and a TCP/IP stack 52. The connection manager 50 is a software implemented device which is typically implemented using the processor 25.

The Bluetooth stack 51 and TCP/IP stack 52 are also software implemented and again this may be achieved by the processor 25. More typically however, the Bluetooth stack and the TCP/IP stack are implemented by the processor in the Access Point interface 21. However, this is not important for the operation of the present invention.

The connection manager 50 controls the operation of the Internet interface 20, the Access Point interface 21, the LAN interface 22 and the PBX interface 23, as well as controlling the transfer of data through the Access Server 1, and the Access Points 2 in accordance with predetermined policy rules.

In this example the Access Server is coupled to an Ethernet phone 55 via the LAN 10, to a standard telephone 56 via the PBX, and to an Internet phone 57, via the Internet 14.

As also shown in Figure 4, the Access Points 2a,2b include respective TCP/IP stacks 60a,60b and Bluetooth stacks 61a,61b. Again, the TCP/IP stack and the Bluetooth stacks 60,61 may be implemented within the Access Server interface 30, or within the processor 32.

In use, data received at one of the Bluetooth radios 3, is typically temporarily stored in the memory 33 before being transferred to the processor 32. At this stage, the Bluetooth stack 61 is used to place the data into the Bluetooth HCI (Host Controller Interface) format suitable for transmission over a connection, such as an RS232 connection, in accordance with the Bluetooth specification.

In the present example, the data is transferred to the TCP/IP stack 60 which converts the data into a format suitable for transmission over the Ethernet connection to the Access Server 1.

Upon receipt of the data at the Access Server 1 the data is transferred to the TCP/IP stack 52 which converts the data back into the Bluetooth HCI format for transfer over the connection to the Bluetooth stack 51. The Bluetooth stack 51 operates to translate the data from HCI format into the basic payload data which can then be transferred onto one of the Internet interface 20, the LAN interface 22 or the PDX interface 23. The routing of the data is achieved in accordance with routing information which is interpreted by the connection manager 50.

The connection manager also determines various information about the Bluetooth connection from the Bluetooth stack 51. This typically includes connection information including an indication of the signal strength of the current connection.

The signal strength can be determined in one of two ways, either as a direct determination of the strength of the signal received at the respective Bluetooth radio 3, or alternatively, or additionally, as an indication of the number of errors occurring per unit time on the connection.

The measurements of signal power are absolute values. However, the output power of a Bluetooth radio is not necessarily fixed and known. Therefore in order to obtain a meaningful measure of the physical separation of two devices, both the transmitted and received signal strengths need to be measured. For example, for two Bluetooth devices, device A and device B, device A measures its transmit power to device B and device B measures the power of the signal received from device A. Then either device A or device B sends its measurement to the other device where the two readings are compared as part of the calculation of physical separation.

The transmission of a power measurement made on device A to device B is made using a Link Manager Protocol (LMP) message or a dedicated L2-CAP connection. Alternatively, a higher layer connection, such as an RF comm channel could be used. Another possibility is a Bluetooth Network Encapsulation Protocol (BNEP) message to communicate received signal strength indicator (RSSI) readings back to the transmitting device. BNEP is a new protocol developed by the BT SIG Personal Area Networking (PAN) WG which runs over L2-CAP and is used for detecting when link quality is bad.

The connection manager 50 then utilises the information to determine the configuration of the network. This is achieved by using the obtained signal strengths to estimate the distance between the two devices currently using the connection. By determining the physical separation of devices using different connections and then comparing these physical separations, it is then possible to determine a network map.

Accordingly, when the network is initially activated, the connection manager 50 will operate to determine a network map.

In order to do this, the connection manager 50 causes each Access Point 2a,2b,2c,2d to form a connection with each other Access Point in the network which is within range. The connection manager 50 determines the signal strength of each temporary connection and uses this to estimate the relative separation of the Access Points 2.

Thus, in the case of the network arrangement shown in Figure 5A, for example, the connection manager 50 first causes the Access Point 2a to initiate a temporary connection with each of the Access Points 2b, 2c, 2d. In this case, connections are only established with the Access Points 2b and 2c. Whilst the connections have been established, the Bluetooth stack 51 will determine basic information regarding the connection, including an indication of the signal strength which is transferred to the connection manager 50.

The connection manager 50 then uses the indication of signal strength to determine the relative separation of the Access Points 2a, 2b and the Access Points 2a, 2c. In this example the antennas of the Access Points 2 are non-directional. Accordingly, it is only possible for the Access Point 2a to determine relative distance of the Access Points 2b, 2c from the Access Point 2a, as shown by the lines 61 and 62 which are contour lines showing the determined separation of the Access Points (hereinafter referred to as separation contours).

In this example, the relative separation between the Access Points 2a and 2d is too great to allow a connection to be established. Accordingly, the connection manager 50 can determine that the Access Point 2d is further away than the distance shown by the maximum range contour line 63, which represents the maximum range of the Access Point 2a. As shown by Figures 5B, 5C and 5D, this process is then repeated for each of the other Access Points.

Thus, as shown in Figure 5B connections are established between the Access Point 2b and the Access Points 2a, 2c and 2d allowing separation contours 64, 65 and 66 to be determined. Furthermore, as shown in Figure 5C, connections are established between the Access Point 2c and the Access Points 2a, 2b, 2d to determine the separation contours 67, 68, 69.

Finally, in Figure 5D connections are established between the Access Point 2d and the Access Points 2b, 2c, to determine the separation contours 70, 71. Again, a connection cannot be established with the Access Point 2a and accordingly, it is only possible to determine that the Access Point 2a is further away than the maximum separation contour 72 which represents the maximum distance via which a connection can be established.

Once the relative separations have been determined, the connection manager 50 uses these to determine the relative location of the Access Points 2a, 2b, 2c, 2b. Thus, as shown in Figure 5E the intersection of the separation contours allows the relative position of the Access Points 2a, 2b, 2c, 2d to be determined.

Thus, the intersection of the separation contours 61, 67 and 71 represents the relative location of the Access Point 2b. Similarly, the intersection of the separation contours 60 and 65 represents relative position of the Access Point 2a, the intersection of the separation contours 62, 64 and 70 represents the relative position of the Access Point 2c, whereas the intersection of the separation contours 66 and 68 represent the relative position of the Access Point 2d.

Accordingly, this allows the connection manager 50 to determine a network map showing the relative separation of the Access Points 2a, 2b, 2c, 2d.

It will be appreciated from this that in fact redundant measurements have been made. Thus, the relative separation of the Access Points 2a and 2b is determined twice, firstly by the separation contour 65 and secondly by the separation contour 61. This is because a connection between the Access Points 2a, 2b was initiated twice, once by the Access Point 2a and once by the Access Point 2b. This provides useful redundancy to allow the relative separation of the Access Points to be more accurately determined. In particular, there may be minor alterations in signal strengths of a connection due to external conditions, such as atmospheric conditions, which are not due to changes in the relative separation of the Access Points. Accordingly, by establishing the connection in both directions, this allows the connection manager 50 to determine the relative separation of the Access Points 2A, 2B as an average of the relative separation calculated in each case.

Thus, assuming that the location of the Access Point 2A is set to be a reference point or origin, it is only necessary to determine the separation contour 61 to determine the relative separation of the Access Points 2a, 2b. The separation contours 62,64 can then be used to determine the position of the Access Point 2c relative to the Access Points 2a,2b. Accordingly, the intersection of the separation contours 64, 62 represents the relative position of the Access Point 2c with respect to the Access Point 2b. Finally, the contour line 66, 68 can be used to determine the relative position of the Access Points 2d with respect to the Access Points 2b, 2c. Thus, as a minimum it is only required to calculate the contours 61, 62, 64, 66, 68.

Once the connection manager has determined the network configuration, it is then possible for the connection manager 50 to determine the relative location of communication devices using the network. Thus, for example, as shown in Figure 6, if a communications device 3 is present it is possible to establish a connection with the communications device 3 from either the Access Points 2a, 2b, 2c. In this case, the communications device 2d is out of range of the communications device 3.

In general, the connection manager 50 would be aware of the presence of the communication device 3 when a single connection is established via one of the Access Points 2a. Accordingly, the connection manager 50 causes additional temporary connections to be established between the communications device 3 and the Access Points 2b, 2c, in order to allow the relative position of the communications device to be determined.

A temporary connection between the Access Point 2b and communication device 3 can be established by causing the Access Point 2b to generate a polling signal to determine if the communications device 3 wants to transmit data. In this case, the communications device 3 is currently already transmitting data via the Access Point 2a and would therefore not respond.

However, the Access Point 2b can ask the communications device 3 if it is ready to receive data in which case a response will be generated by the communications device 3 indicating it is available. The Access Point 2b receives the response from the communications device 3 and utilises this to determine the required signal strength.

Accordingly, as in the determination of the network map described with respect to Figures 5A to 5E, the connection manager 50 determines separation contours 73, 74, 75 representative of the separation of the communications device with the Access Points 2a, 2b, 2c respectively. In this case the point at which all three of the separation contours 73, 74, 75 intersect represents the location of the communications device 3 as shown.

By constantly repeating this process, this allows the connection manager to constantly monitor the location of the communications devices 3, 4, 5, 6, 7, 8 relative to the network.

This aspect of the present invention can be extended by providing user associations with the identity of respective communications devices 3, 4, 5, 6, 7, 8. This is normally achieved by operating a registration procedure to control the access of users to the system. Thus, the Access Server 1 typically stores a list of authorised users in the memory 26. In each case, details of the user are associated with a device indication representative of the communications device(s) 3, 4, 5, 6, 7, 8 which the respective user uses. Thus for example, the MAC (Medium Access

Control) address, or assigned IP address of a PDA would be associated with an indication of the PDA's owner such that, once the location of the PDA has been determined, this also identifies the location of the user.

Typically in networks according to the present invention, the registration procedure is also used to ensure that only authorised users of the system have access. This can be achieved simply by ensuring that only devices with a predetermined device indication, such as predetermined MAC or IP address, can connect to the network. Alternatively however the Access Server 1 can store a list of user names and associated passwords in the memory 26. Accordingly, in this case if a user were to require a wireless connection via a network, it will be necessary for the user to enter a user name and password and transmit this via the Bluetooth connection to the network.

It will be appreciated that in this example the system can advantageously be arranged to receive the user name and password at each of the Access Points 2a, 2b, 2c which is in the range of the respective communications device 3. This would allow the location of the communications device 3 to be identified when it first logs onto the network.

This in turn may allow a restriction on the physical location which the communications devices are used. Accordingly, it is possible to define dead areas in which communications devices 3, 4, 5, 6, 7, 8 may not be used. This may be necessary for example to prevent a communications device located outside a building from establishing a wireless connection via an Access Point located inside the building. Thus for example, as shown in Figure 6 if the line 76 represents the edge of the building containing the Access Points it is possible to ensure that the connection device 3 is unable to communicate with the network by establishing that its location is outside the building.

In order to achieve this, it would be necessary for the system administrator to define areas on the network map in which the communications devices should not function.

A further benefit of the present invention is that as it can be used to track movement of communications devices throughout a network area, it can also be used to activate building functions, such as lighting, heating, door locks and alarms. Thus, for example, as shown in Figure 7 it is possible for a system administrator to program in to the Access Server 1 details of the locations of rooms within the building, with respect to the determined network map.

As shown in this example the building 80 includes a corridor 81 and six rooms 82, 83, 84, 85, 86 and 87. By monitoring the location of a communications device 3 it is possible for the connection manager 50 to control lighting within the building.

Thus, in the situation shown in Figure 7, the connection manager 50 would determine that the communications device 3 is located in the room 84. Accordingly, the connection manager could ensure that alarms are activated in the remaining rooms 82, 83, 85, 86 and 87, as well as ensuring that lights are only switched on in the room 84. If the communications device should then exit the room 84 and enter the corridor 81, the connection manager could cause light in the corridor 81 to be activated and light in the room 84 to be deactivated. Similarly, other features, such as door locks, heating and the like may also be controlled.

It will of course be realised that users would not necessarily always carry a communications device 3, 4, 5, 6, 7, 8, on their person, particularly if the communications device were a laptop or the like. Accordingly, it is possible to provide security tags including a Bluetooth transceiver. Each security tag would be adapted to transmit a unique identifier code representative of the respective tag. This could be done either at periodic intervals, or in response to a polling signal. This can then be used to allow the location of the security tags, and hence the location of the users to be monitored.

In this example, it is of course necessary to program the Access Server 1 to control light fittings in certain rooms in accordance with the location of the respective communications device 3.

This can to a certain extent be overcome by ensuring that the building functions are controlled using a Bluetooth enabled function controller. Accordingly, by fitting a Bluetooth enabled function controller to each light in the building, is possible for the Access Server 1 to automatically determine the location of the lights.

An example of this is shown in Figure 8.

As shown, each room includes a respective light controller 91, 92, 93, 94, 95, 96, 97. The location of these can be identified in the manner described above with respect to calculating the initial network map. Once the location of the controller has been determined, if a communications device is identified to be within a certain range of the respective controller, the controller can be activated to turn on the lights.

Thus, if it sensed that the communications device 3 is within a predetermined distance of the function control 94, as shown by the separation contour 98, then this can cause the function controller 9 to be activated to turn on the lights within the room.

It will be appreciated from this diagram that it is not always possible to locate the communications device 3 in the room exactly if this automatic detection is used. However, this system would be ideal for use in large buildings, such as warehouses, airports or the like where lights could be activated in the region of the communications device 3.

This system could also be used with door locks which would allow the position of the doors to be determined and this in turn could be used for activating features such as lighting or the like.

The above examples have been described in a two-dimensional fashion in which it is assumed that the Access Points are distributed throughout a plane, for example on a single floor within a building.

However, it is equally possible to apply the present invention to a three-dimensional environment in which Access Points are distributed throughout a three-dimensional space. This would typically occur, for example, in a building where Access Points are located on different floors of the building as well as being distributed on each floor.

However, the system of the present invention will operate to function in a similar manner with the separation contour lines being replaced by separation contour spheres representing the distance from the Access Point to the other communicating device (including communication devices 3,4,5,6,7,8 or other Access Points 2). The intersection of these spheres would again be used to locate the devices and hence generate the network maps.

A final example of the present invention will now be described with reference to Figure 9. In this example, the Access Points 2a,2b,2c,2d each include two directional antennas. As a result, each Access Point 2a,2b,2c,2d is able to detect signals originating in predefined footprint areas. Thus, as shown for the Access Point 2a, the two directional antennas define two footprint areas 100,101 as shown in Figure 9.

In use, an approximate estimation of the location of the Access Points 2b,2c relative to the Access Point 2a can therefore be determined in accordance with information regarding the signal strength and the antenna via which the signal was detected. Thus, for example, if a signal is detected from the Access Point 2b it will be determined that this falls within the footprint area 100. In addition to this, information concerning the signal strength can be used to determine a separation contour 102, as shown allowing the location of the Access Point 2b to be located to within a certain degree of confidence.

It will be appreciated by a person skilled in the art, that as additional measurements are made by other ones of the LADs, this can result in more accurate determination of position.

Furthermore, with the use of a larger number of antennas with greater directional characteristics, the size of the footprint area can be reduced thereby further increasing the accuracy with which the relative location of the Access Points can be determined.

Finally of course it would also be possible to have overlapping footprint areas for different antennas at the same location. In this case the location of an Access Point or other communications device which falls within the overlap between these two footprint areas could be determined relatively accurately using the separation and direction information from the one Access Point, as will be appreciated by a person skilled in the art.

CLAIMS

1. A network for providing wireless connectivity to wireless enabled communications devices, the network comprising:

a number of interconnected transceivers, each transceiver being capable of establishing wireless connections; and,

a processor coupled to the transceivers, the processor being adapted to:

monitor wireless connections provided by at least some of the transceivers with other network elements;

determine selected information regarding the wireless connections; and,

determine a network configuration based on the selected information.

2. A network according to claim 1, wherein the selected information includes an indication of the signal strength of the respective connection, the processor being adapted to determine the relative physical separation of the network element and the respective transceiver in accordance with the determined signal strength.

3. A network according to claim 2, wherein the indication of signal of the signal strength of the respective connection between a first device and a second device includes both the transmitted signal strength at the first device and the received signal strength at the second device.

4. A network according to claim 1 or claim 2, wherein the transceivers include a directional antenna and wherein the selected information includes an indication of a connection direction, the processor being adapted to determine the direction of the network element relative to the respective transceiver.

5. A network according to any of the claims 1 to 3, wherein the other network elements include other ones of the transceivers, the network configuration representing at least the relative physical locations of the transceivers.

6. A network according to claim 4, wherein the processor determines the signal strength of wireless connections between the transceivers by causing a transceiver

to establish one or more temporary connections with one or more of the transceivers, and then determine the signal strength of the temporary connection(s).

7. A network according to any of claims 1 to 5, wherein the other network elements include communications devices, and wherein the network configuration includes an indication of the relative physical location of the communications devices.

8. A network according to claim 6, wherein the processor is adapted to monitor movement of the communications devices relative to the network in accordance with the network configuration.

9. A network according to claim 7, wherein the network includes a store for storing user information defining relationships between users of the network and their respective communications devices, the processor being further adapted to monitor the location of the users in accordance with the network configuration.

10. A network according to any of claims 6 to 8, wherein the processor is further adapted to control at least one building function, the processor being adapted to control the function in accordance with the relative physical location of the communications devices.

11. A network according to claim 9, wherein the building functions include at least one of heating, lighting, door locks and alarms.

12. A network according to claim 10, wherein each building function is controlled by a respective wireless enabled function controller, the function controllers being responsive to commands received from the processor via wireless connections.

13. A network according to claim 11, wherein the other network elements including the function controllers, the network configuration representing at least the relative physical locations of the function controllers, the processor being further adapted to determine the relative location of the building functions in accordance with the network configuration.

14. A network according to any of the preceding claims, wherein the network includes:

a number of interconnected network nodes, each node including at least one respective transceiver; and,

a network server coupled to the network nodes, the network server including the processor.

15. A network according to claim 13, wherein the network nodes comprises Access Points.

16. A network according to claim 13 or claim 14, wherein the network server comprises an Access Server.

17. A method of determining the configuration of a network, the network being formed from a number of interconnected transceivers, each transceiver being capable of establishing wireless connections with wireless enabled communications devices, the method comprising:

monitoring wireless connections provided by at least some of the transceivers; with other network elements;

determining selected information regarding the wireless connections; and,

determining the network configuration based on the selected information.

18. A method according to claim 16, wherein the selected information includes an indication of the signal strength of the respective connection, the method comprising determining the relative physical separation of the network element and the respective transceiver in accordance with the determined signal strength.

19. A method according to claim 16 or claim 17, wherein the transceivers include a directional antenna and wherein the selected information includes an indication of a connection direction, the method further comprising determining the direction of the network element relative to the respective transceiver.

20. A method according to any of claims 16 to 18, wherein the method comprises monitoring connections established with other transceivers to thereby determine the relative physical locations of the transceivers.

21. A method according to any of claims 16 to 19, wherein the method comprises monitoring connections established with communications devices to thereby determine the relative physical locations of the communications devices.

22. A method according to claim 20, wherein the method further comprises controlling at least one building function in accordance with the relative physical location of the communications devices.

Fig.1.

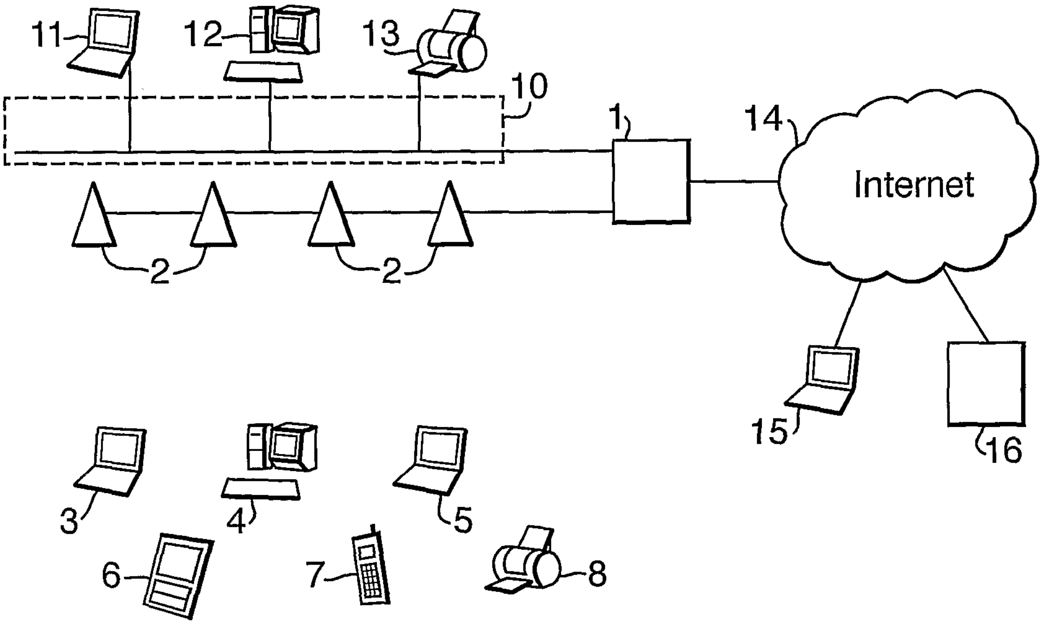

11
12
13
10
1
14
Internet
2
2
15
16
3
4
5
6
7
8

Fig.2.

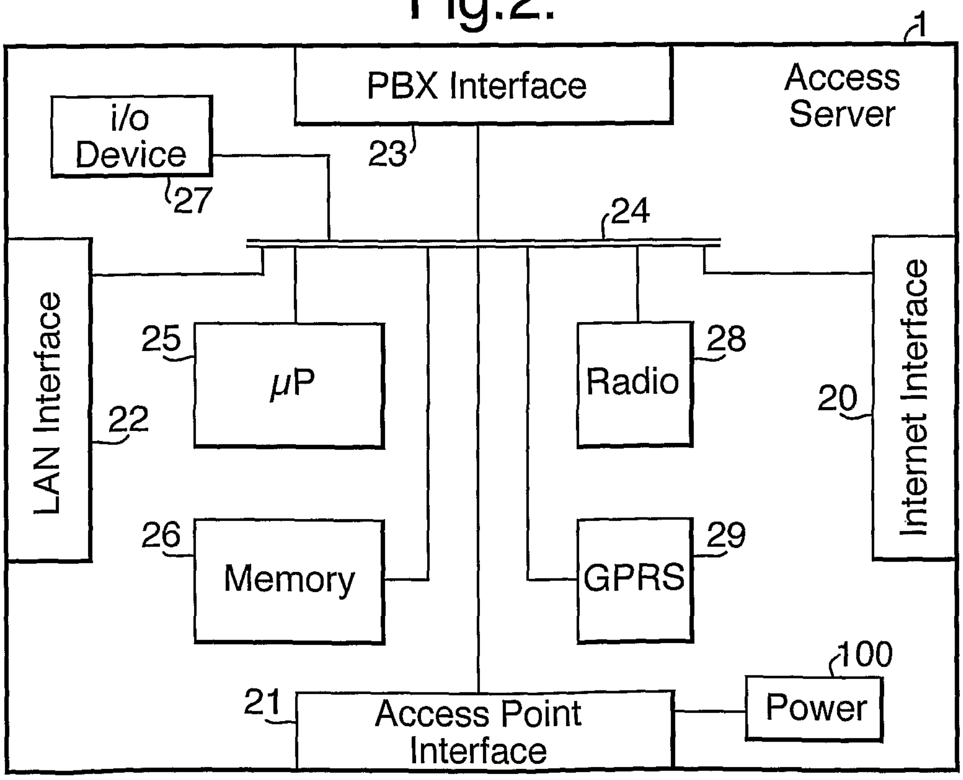
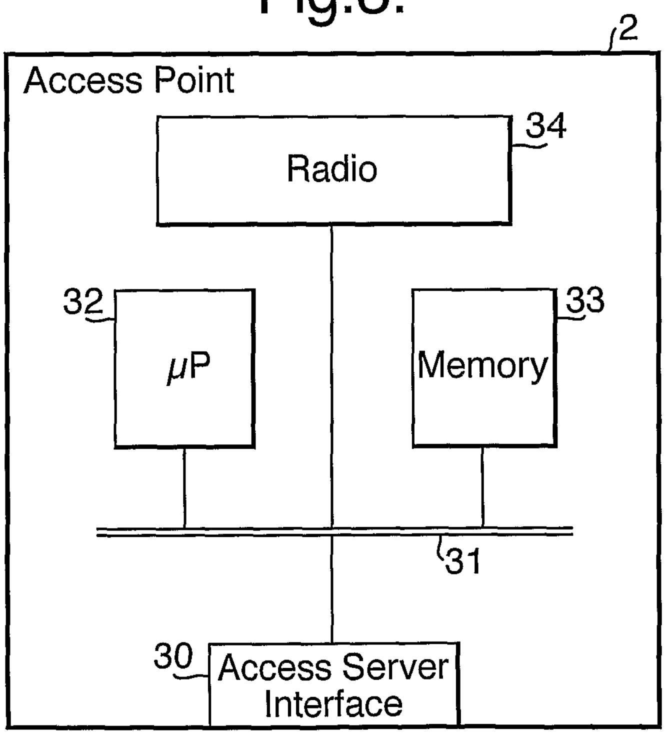

1
PBX Interface
Access Server
i/o Device
23
27
24
LAN Interface
Internet Interface
25
μP
28
Radio
22
20
26
Memory
29
GPRS
100
21
Access Point Interface
Power

Fig.3.


2
Access Point
Radio
34
32
μP
Memory
33
31
30
Access Server Interface

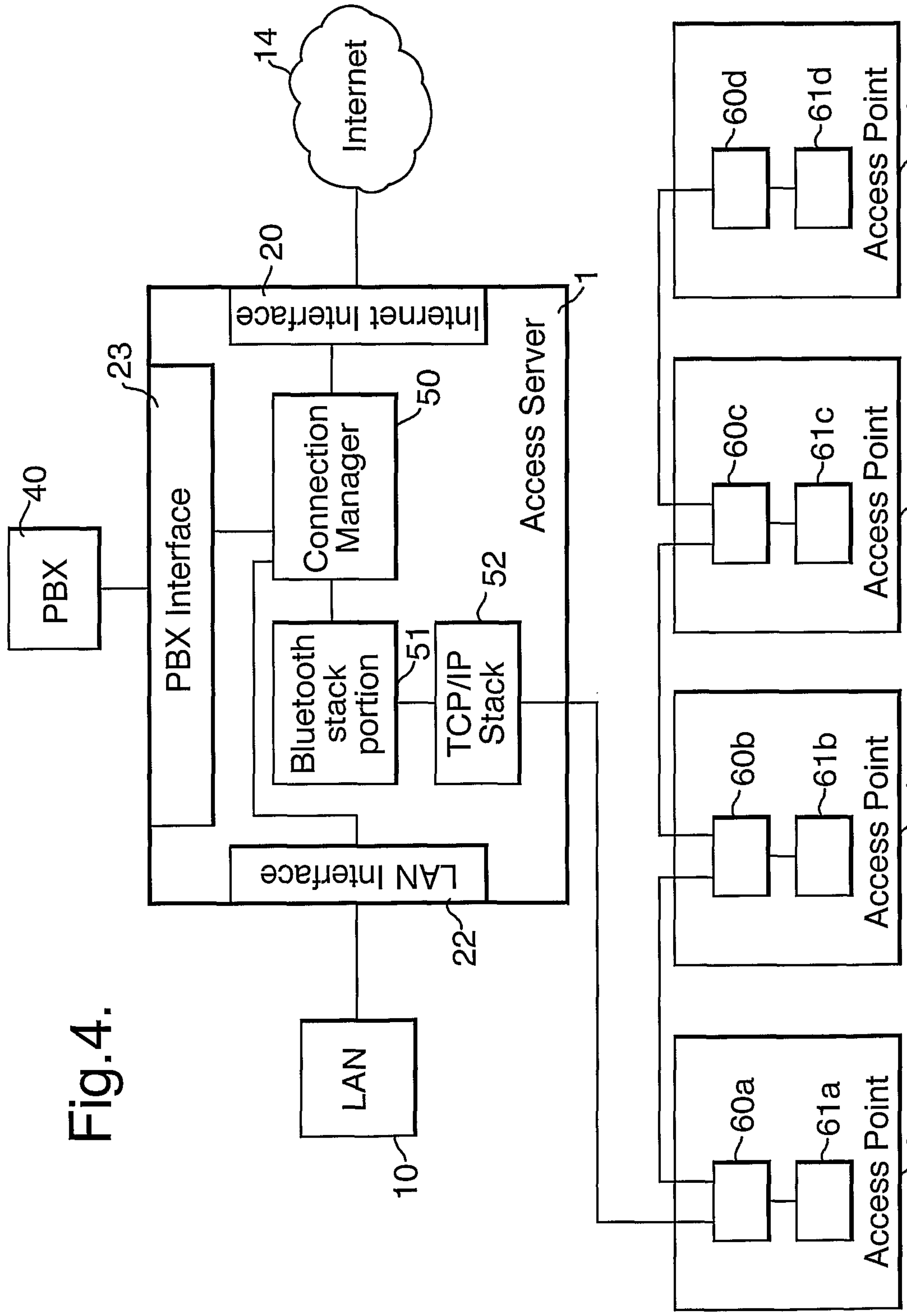

Internet
14
20
Internet Interface
1
Access Server
PBX
40
PBX Interface
23
Connection Manager
50
Bluetooth stack portion
51
TCP/IP Stack
52
LAN Interface
22
LAN
10
60a
61a
Access Point
2a
60b
61b
Access Point
2b
60c
61c
Access Point
2c
60d
61d
Access Point
2d

Fig.4.

Fig.5A.

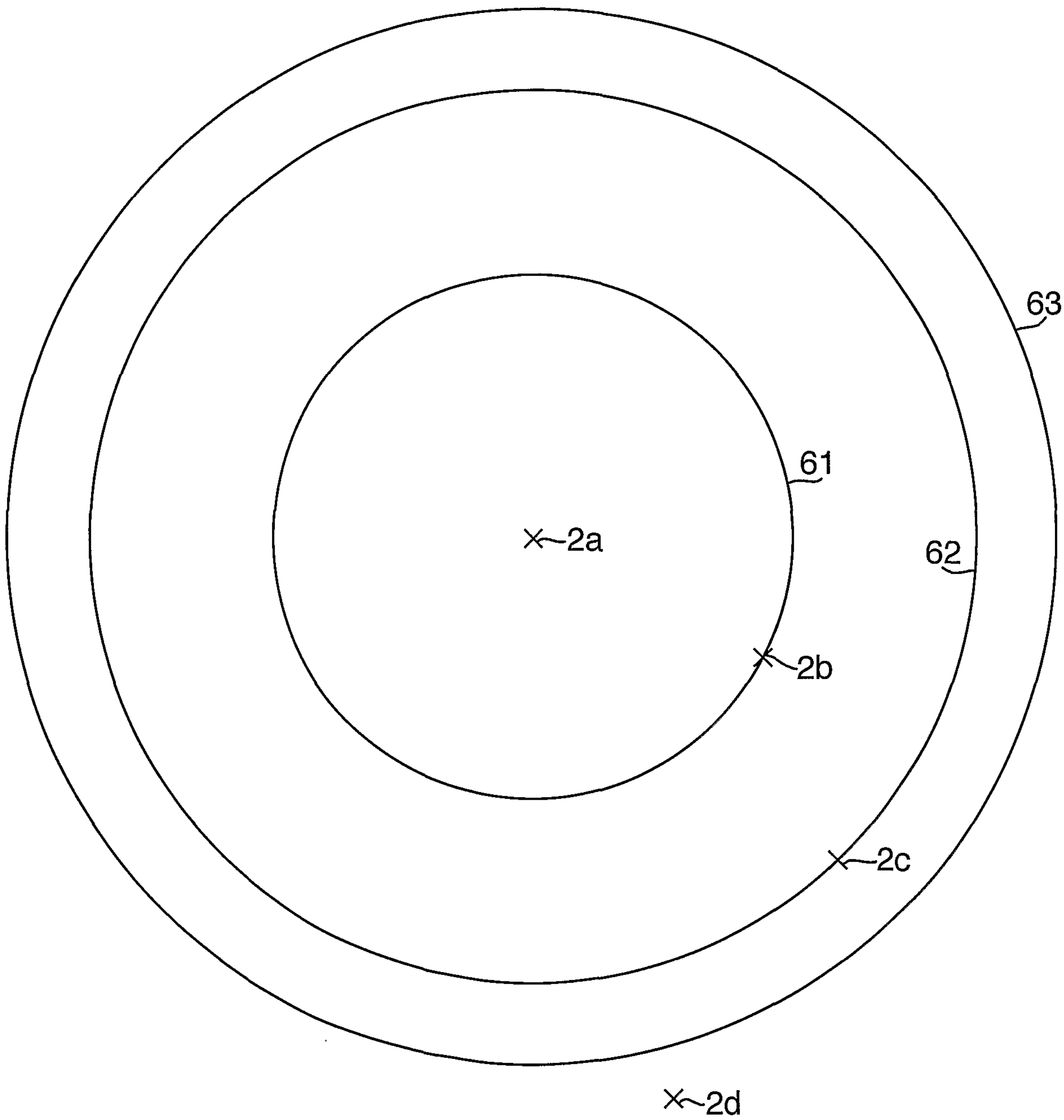


Fig.5B.

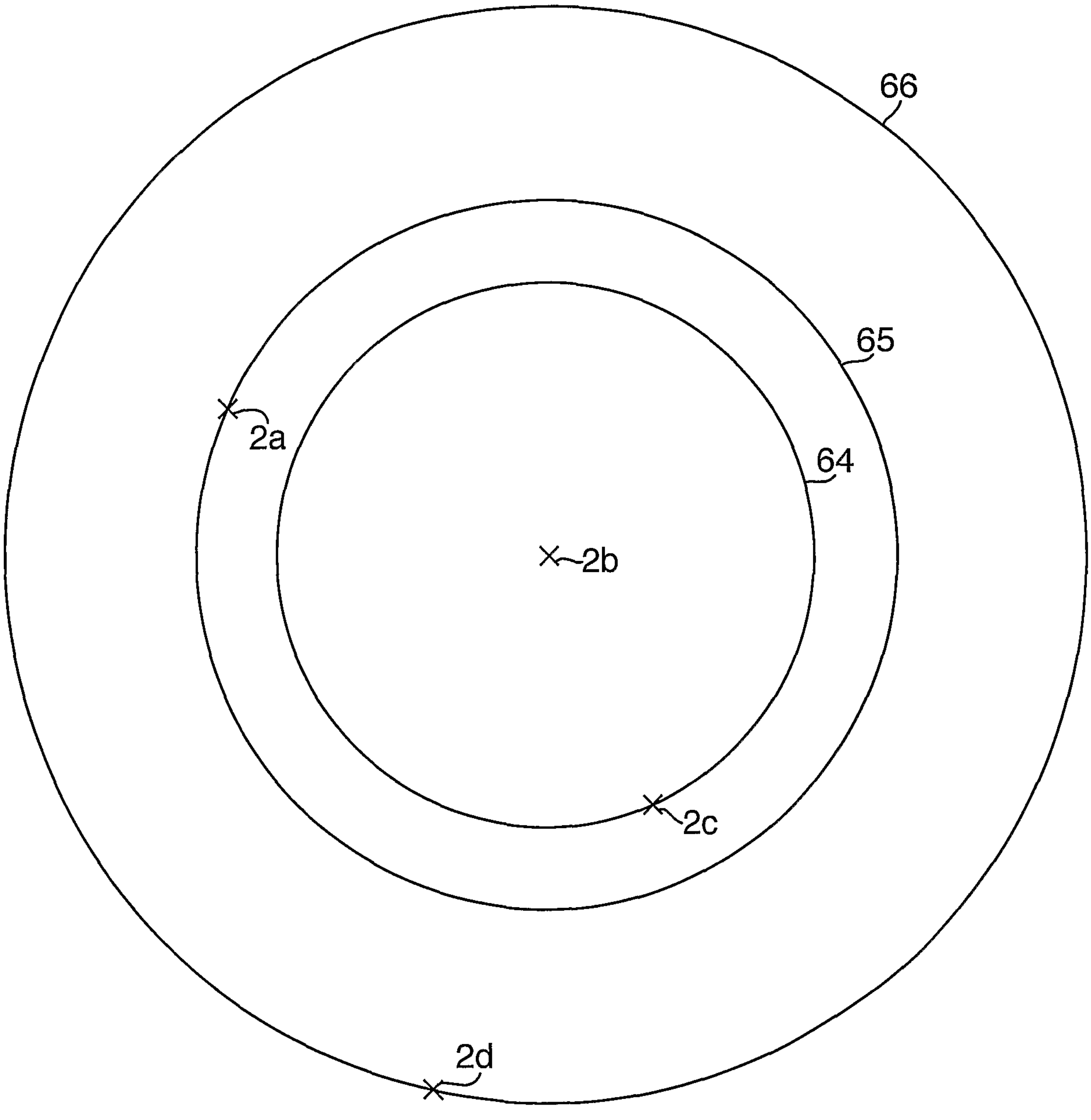


Fig.5C.

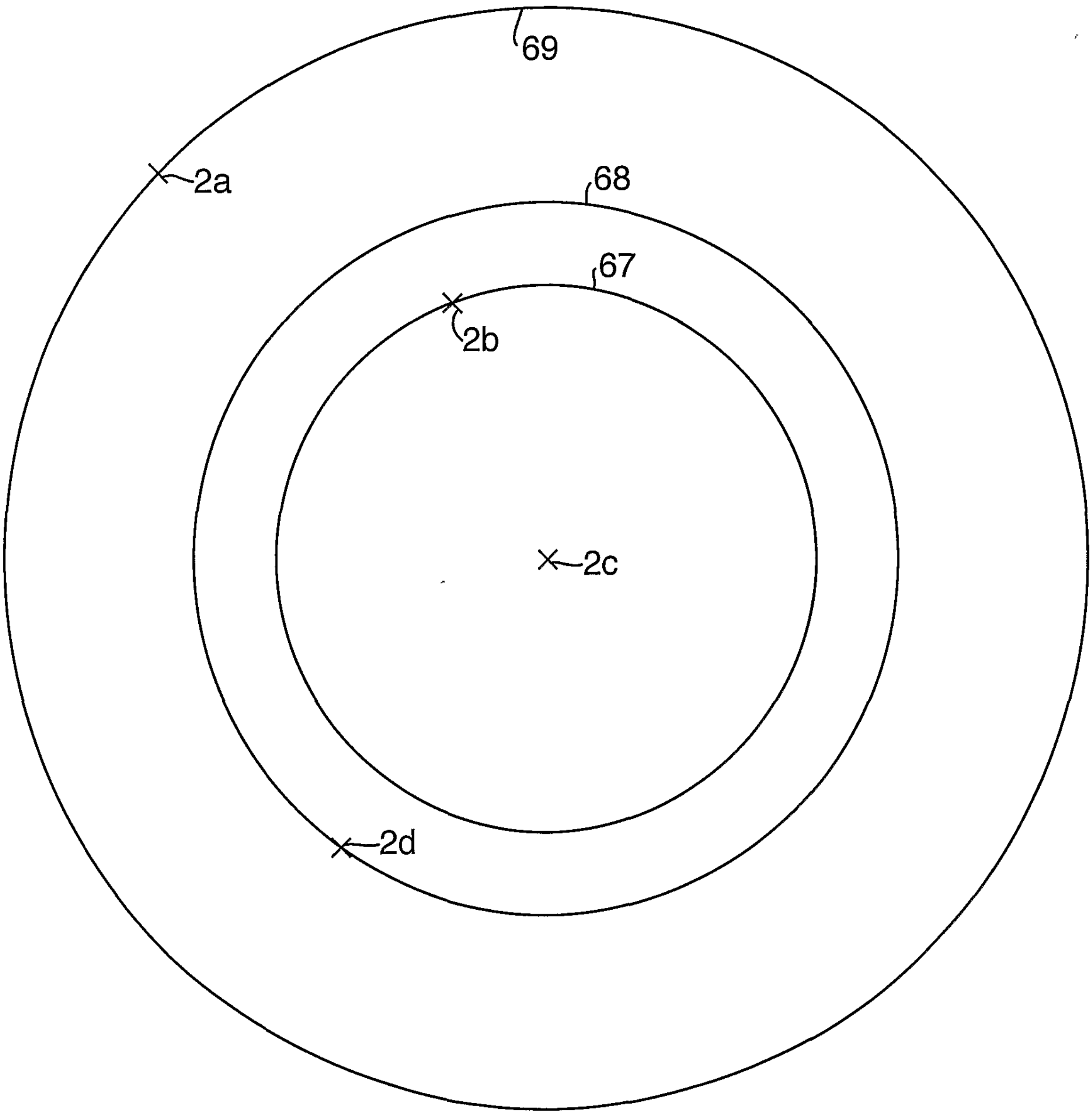


Fig.5D.

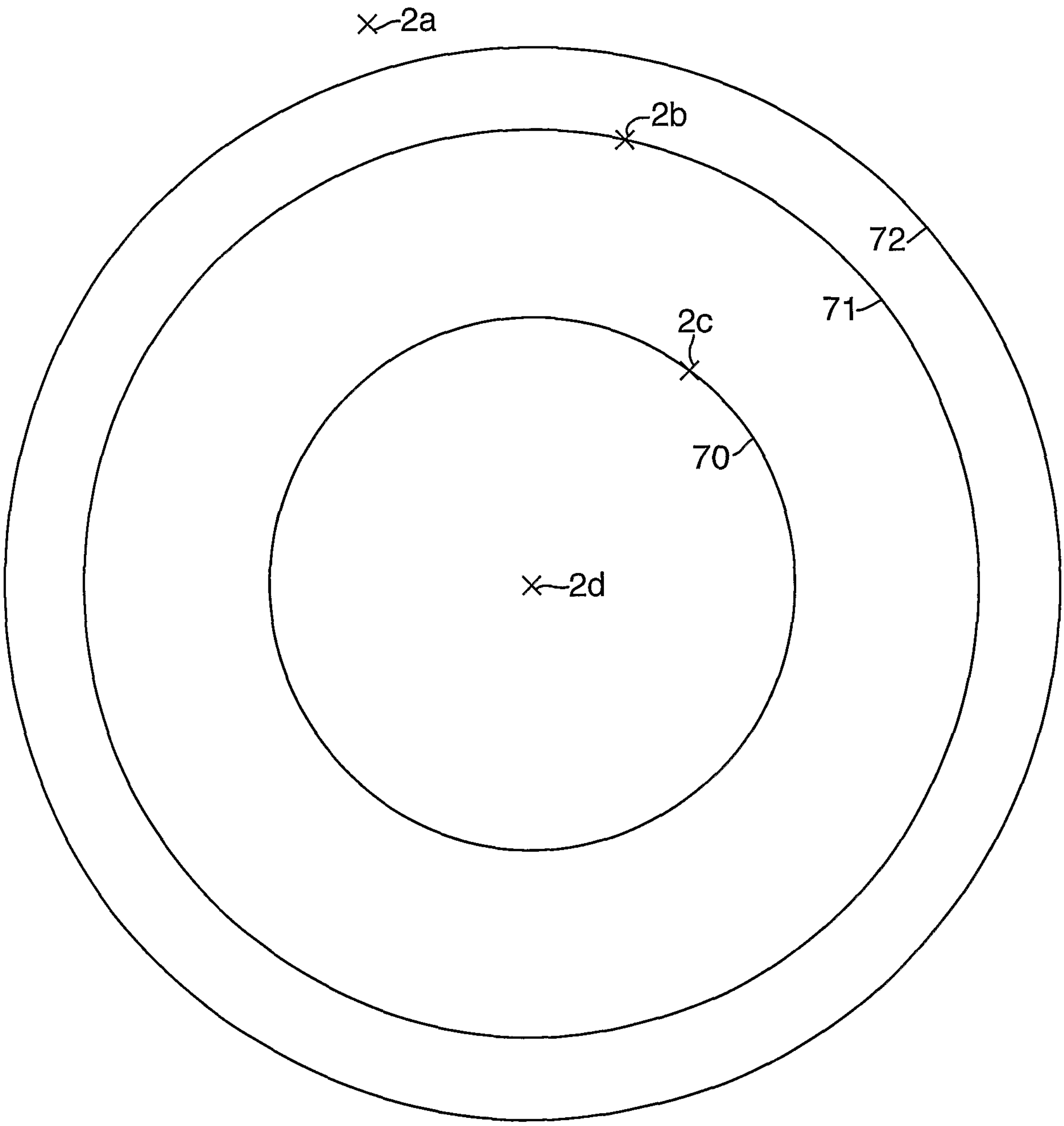


Fig.5E.

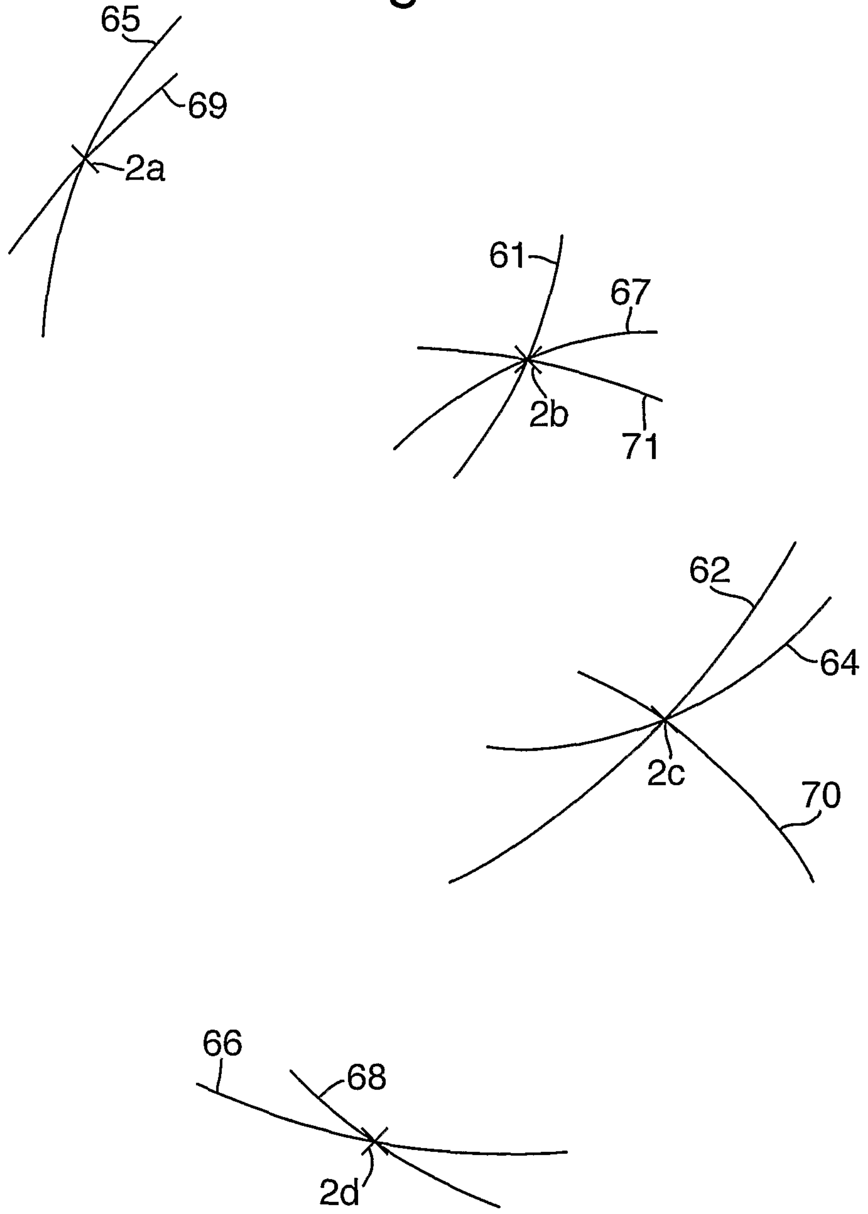


Fig.6.

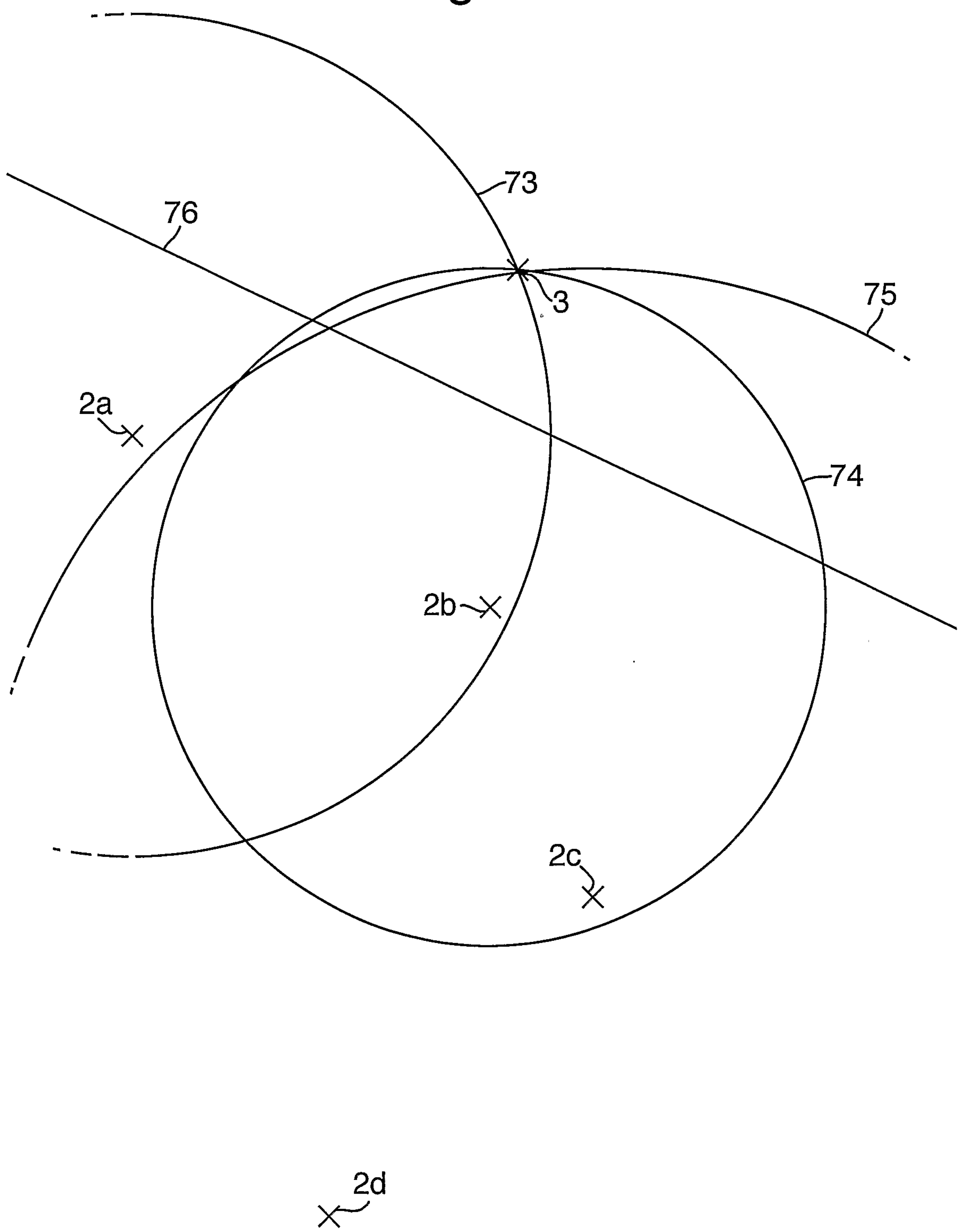


Fig.7.

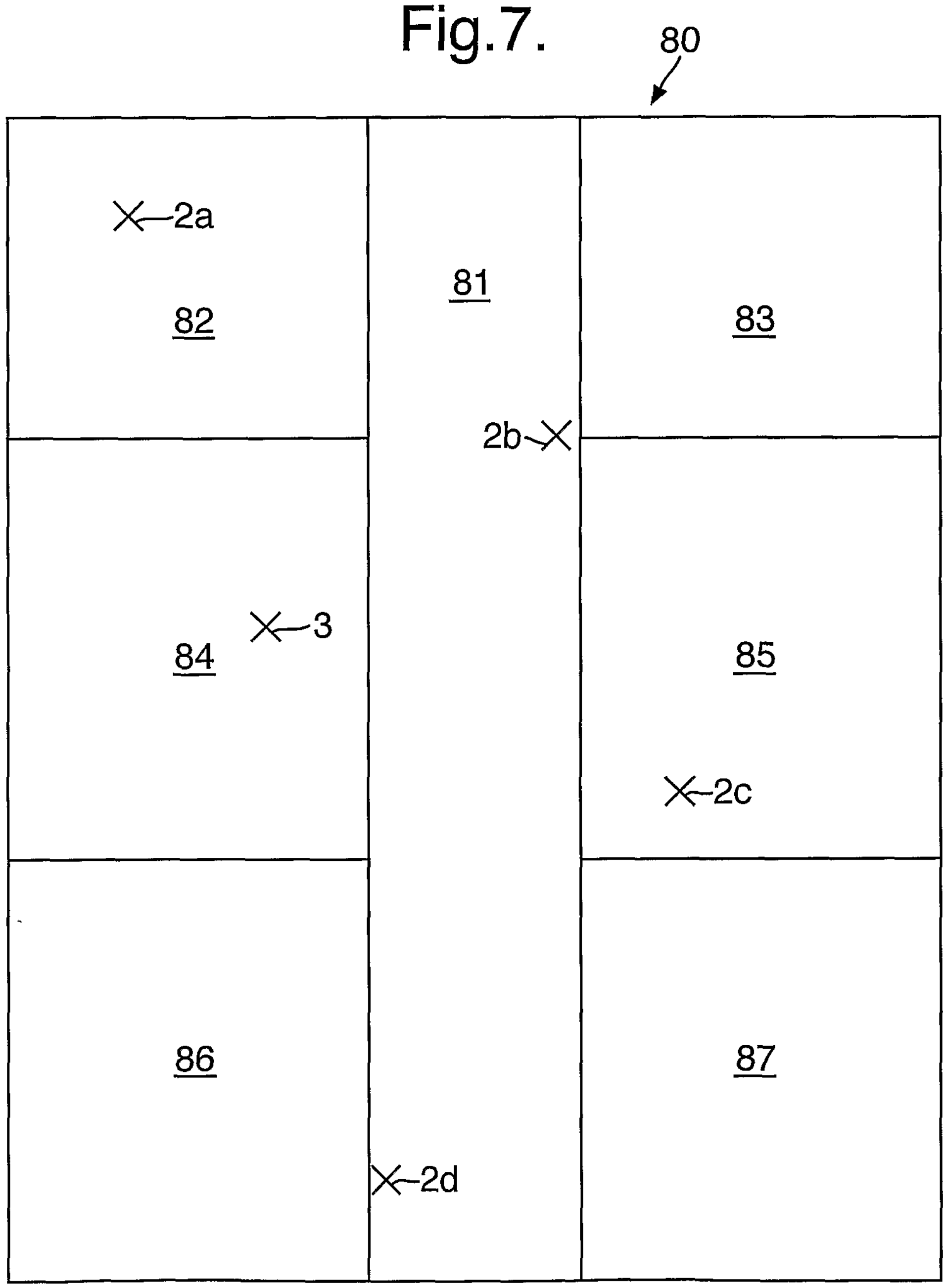


Fig.8.

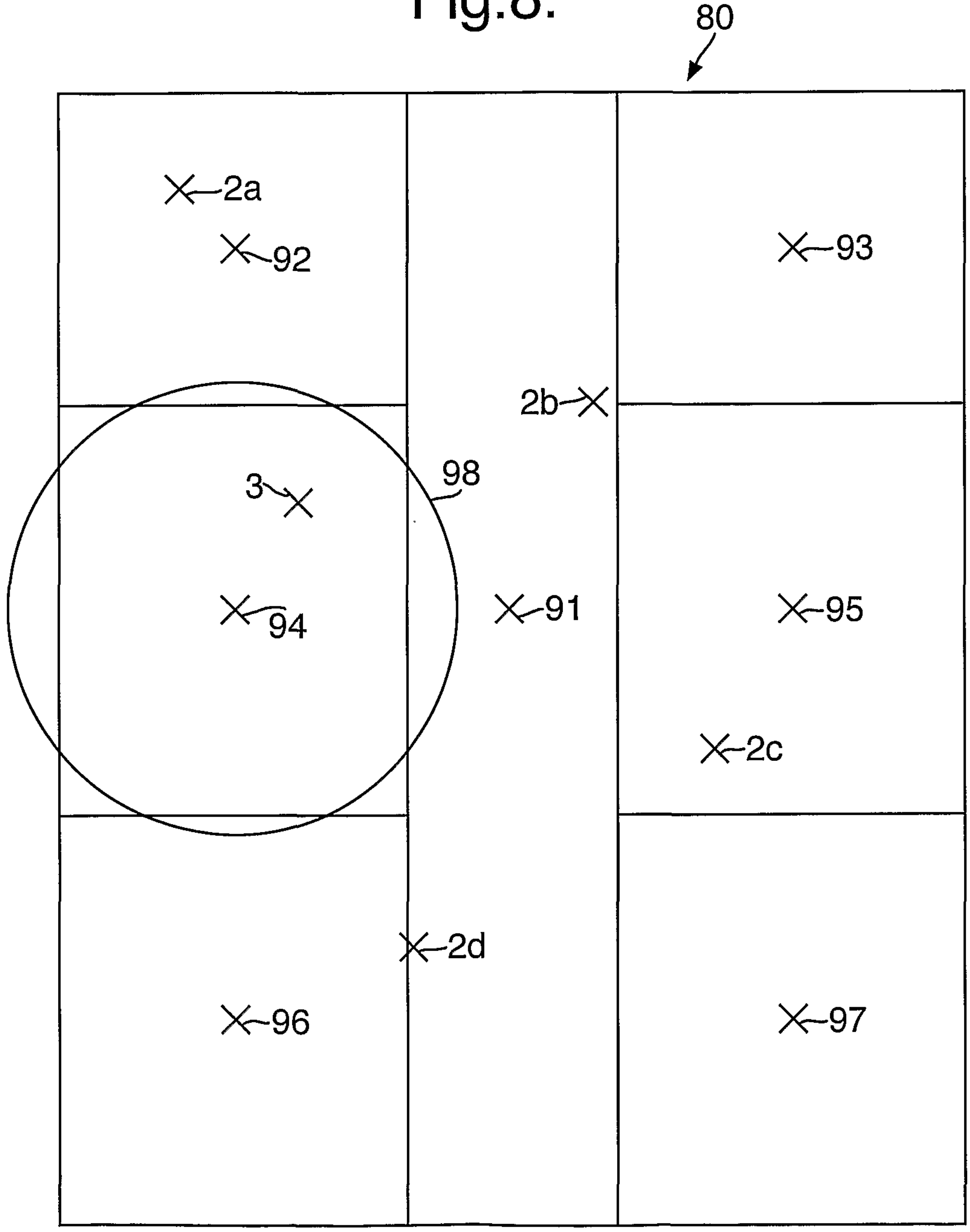
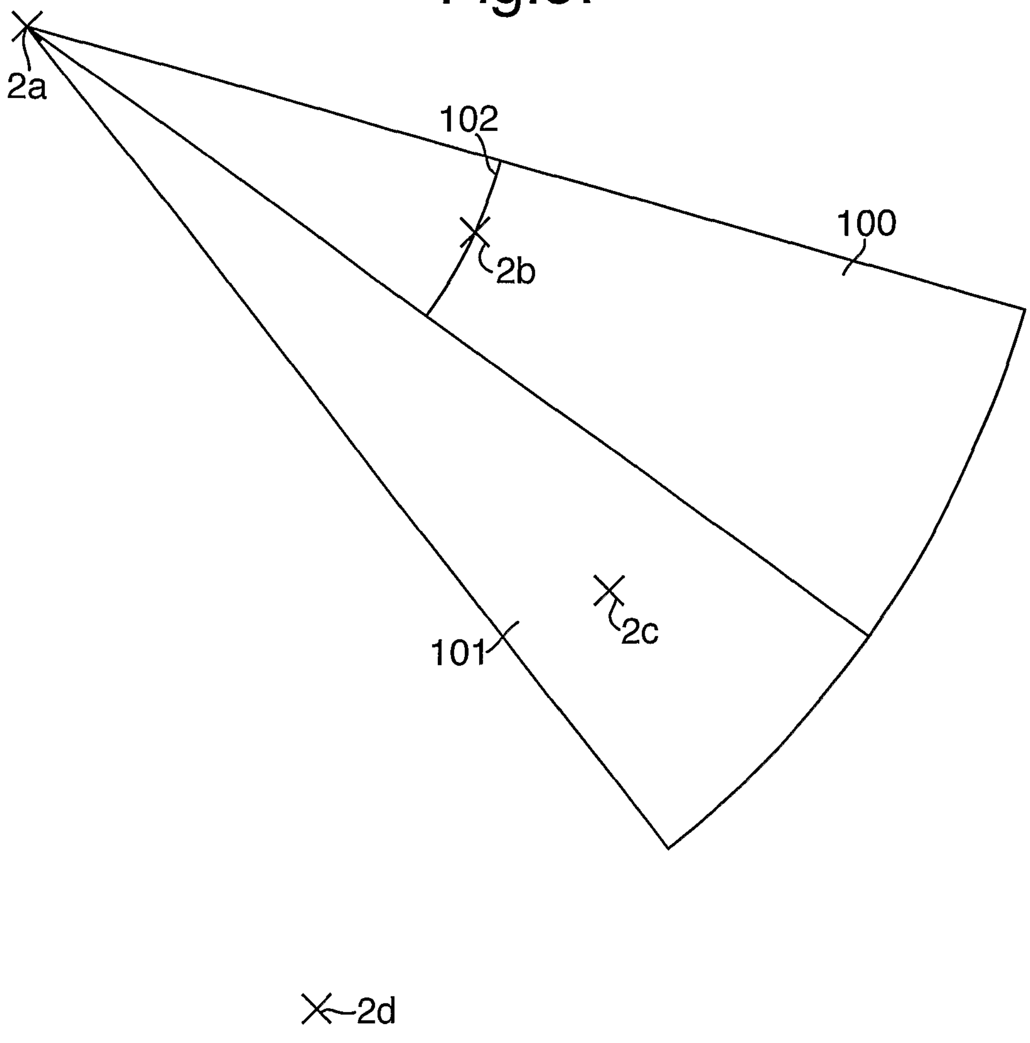


Fig.9.



INTERNATIONAL SEARCH REPORT

Int ıl Application No
PCT/GB 01/02606

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04B H05B G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 5 838 926 A (YAMAGISHI YOICHI) 17 November 1998 (1998-11-17)	1,2,5-7, 9,14,17, 18,20,21
Y	column 3, line 25 - line 38 column 4, line 21 - line 31 column 8, line 5 - line 17 column 11, line 13 - line 54 ---	10-13,22
Y	WO 00 17737 A (KONINKL PHILIPS ELECTRONICS NV) 30 March 2000 (2000-03-30) page 3, line 30 -page 4, line 17 page 5, line 21 - line 22 page 10, line 12 - line 15 page 10, line 25 - line 28 page 13, line 25 -page 14, line 3 ---	10-13,22

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 October 2001	26/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	M. Garcia

INTERNATIONAL SEARCH REPORT

Int Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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