CONVENTION

AUSTRALIA

Patents Act 628087

APPLICATION FOR A STANDARD PATENT

Motorola Inc.
1303 E. Algonquin Road, Schaumburg, Illinois, UNITED STATES OF AMERICA

hereby applies for the grant of a standard patent for an invention entitled:

SATELLITE CELLULAR TELEPHONE AND DATA COMMUNICATION SYSTEM

which is described in the accompanying complete specification.

Details of basic application(s):-
263,849 UNITED STATES OF AMERICA 28 October 1988

Address for Service:

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DATED this TWENTY SECOND day of SEPTEMBER 1989

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By:

Our Ref : 147049
POF Code: 1437/1437

M 012592 220989

6010

CR01813

Commonwealth of Australia
The Patents Act 1952

DECLARATION IN SUPPORT

In support of the (Convention) Application made by:

MOTOROLA, INC.

of 1303 E. Algonquin Road
Schaumburg, Illinois 60196
United States of America

for a patent for an invention entitled: SATELLITE CELLULAR TELEPHONE AND DATA COMMUNICATION SYSTEM

I, Vincent J. Rauner, Senior Vice President, Patents, Trademarks and Licensing,

of and care of the applicant company do solemnly and sincerely declare as follows:

I am authorised by the applicant for the patent to make this declaration on its behalf.

The basic application as defined by section 141 (142) of the Act was made on 28 October 1988 in the United States of America under Serial No. 263,849.

The basic application referred to in this paragraph is the first application made in a Convention country in respect of the invention the subject of the application.

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all of the United States of America,

are the actual inventors of the invention and the facts upon which MOTOROLA, INC. is entitled to make the application are as follows:

The inventor(s) made the invention during the course of their employment with applicant; applicant is the assignee of the actual inventor(s).

Declared at Schaumburg, Illinois, U.S.A., this 11th day of August, 1989.

MOTOROLA, INC.

By: Vincent J Rauner

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(12) PATENT ABRIDGMENT (11) Document No. AU-B-41693/89
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 628081

(54) Title
SATELLITE CELLULAR TELEPHONE AND DATA COMMUNICATION SYSTEM

International Patent Classification(s)
(51)[4] H04B 007/26 H04B 007/005 H04B 007/185

(21) Application No. : 41693/89 (22) Application Date : 22.09.89

(30) Priority Data

(31) Number (32) Date (33) Country
263849 28.10.88 US UNITED STATES OF AMERICA

(43) Publication Date : 03.05.90

(44) Publication Date of Accepted Application : 10.09.92

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(56) Prior Art Documents
US 3497807
AU 597126 81706/87 H04B 7/185

(57) Claim

1. A non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to at least one of said plurality of satellite switching means establishing a communication link between selected ones of said users via said satellite switching means; and

means for handing-off the communication link between said satellite switching means.

AUSTRALIA

Patents Act

60081

COMPLETE SPECIFICATION
(ORIGINAL)

Class Int. Class

Application Number:
Lodged:

Complete Specification Lodged:
Accepted:
Published:

Priority

Related Art:

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Complete Specification for the invention entitled:

SATELLITE CELLULAR TELEPHONE AND DATA COMMUNICATION SYSTEM

Our Ref : 147049
POF Code: 1437/1437

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

6006

SATELLITE CELLULAR TELEPHONE AND DATA COMMUNICATION SYSTEM

The present invention pertains to global mobile communications and more particularly to a satellite cellular telephone and data communication system.

Present geostationary satellite communication systems allow point-to-point communication. That is, the satellite functions as a relay station or a "bent pipe". The satellite simply receives information from one point on earth and transmits it to another fixed point on earth.

One such point-to-point satellite communication system is shown in U.S. Patent 4,720,873. This system shows point-to-point communications through a satellite for network programming and advertising purposes.

Some basic multiplexing functions may be supplied within the satellites of a satellite communication system. One such system is shown in U.S. Patent 4,480,328. This patent teaches a satellite communication system in which the satellite is a relay station for TDMA multiplexed data.

The above-mentioned systems and other systems teach the use of a single satellite for communications from one point to another. These satellite systems show no selectivity or switching of data among a plurality of users.

According to one aspect of the present invention there is provided a non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to at least one of said plurality of satellite switching means establishing a communication link between selected

ones of said users via said satellite switching means; and

means for handing-off the communication link between said satellite switching means.

According to a further aspect of the present invention there is provided a non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to said satellite switching means establishing a communication link between selected ones of said users or a said satellite switching means;

means for handing-off the communication link between said satellite switching means; and

said link means further coupling said satellite switching means to a public switched telephone network means, other ones of said users being connected to said public switched telephone network means, said public switched telephone network means operating to selectively connect users of said public switched telephone network means with users directly coupled to said satellite switching means via said link means.

According to a still further aspect of the present invention there is provided a non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users

to said satellite switching means establishing a communication link between selected ones of said users via said satellite switching means;

means for handing-off the communication link between said satellite switching means; and

date base means coupled to said satellite switching means via said link means, said date base means for storing and transmitting switching information describing each of said plurality of users.

According to a still further aspect of the present invention there is provided a non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to said satellite switching means establishing a communication link between selected ones of said users via said satellite switching means;

means for handing-off the communication link between said satellite switching means;

cellular telephone means having a control signal for connecting each of said users to said satellite switching means via said link means;

data base means coupled to said satellite switching means via said link means, said data base means for storing and transmitting switching information describing each of said plurality of users; and

said satellite switching means operating in response to said control signal of each of said user's cellular telephone means to update said data base means with a present location of each user.

According to a still further aspect of the present invention there is provided a satellite cellular

communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for being positioned in low-earth orbit about the earth;

link means for coupling at least one of said users to said satellite switching means establishing a communication link between selected ones of said users via said satellite switching means; and

means for handing-off the communication link by the satellite switching means.

According to a still further aspect of the present invention there is provided a satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for being positioned in non-geosynchronous orbit;

first link means for coupling said users to said satellite switching means establishing a communication link between selected ones of said users via at least one of said plurality of satellite switching means;

means for handing-off the communication link between said satellite switching means; and

second link means for permitting multidirectional communication between one of said plurality of satellite switching means of a first satellite and any adjacent one of said plurality of satellite switching means of a second satellite.

According to a still further aspect of the present invention there is provided a satellite cellular communication system for communicating among a plurality

of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for use in non-geosynchronous orbit;

link means for coupling said users to said satellite switching means establishing a communications link between selected ones of said users via at least one of said plurality of satellite switching means; and

means for handing-off the communication link between said satellite switching means.

According to a still further aspect of the present invention there is provided a method of communicating in a non-geosynchronous satellite cellular system, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile subscribers, comprising:

a subscriber communicating with a satellite; and

handing-off that ongoing communication to another satellite.

According to a still further aspect of the present invention there is provided a method of communicating in a non-geosynchronous satellite cellular system, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile subscribers, comprising:

a subscriber communicating with a satellite; and

contemporaneously terminating the communication via the communicating satellite and re-establishing the communication via another satellite, whereby the continuity of the communication is substantially maintained.

According to a still further aspect of the present invention there is provided a satellite cellular system,

where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile subscribers, comprising:

means for a subscriber communicating with a satellite in non-geosynchronous orbit; and

means for handing-off that ongoing communication to another satellite in non-geosynchronous orbit.

According to a still further aspect of the present invention there is provided a non-geosynchronous cellular satellite for use in a satellite cellular system in non-geosynchronous orbit, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile subscribers, comprising:

means for receiving at a satellite communication; and

means for handing-off that ongoing communication to another satellite.

According to a still further aspect of the present invention there is provided a non-geosynchronous satellite communication system for establishing communication between at least two users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and users including a plurality of satationary/mobile subscribers, comprising:

satellite switching means comprising a first and second satellite positioned in earth orbit for initiating and sustaining communication between the users; and

means for handing-off a communication initiated through the first satellite to the second satellite during the communication.

According to a still further aspect of the present invention there is provided a non-geosynchronous satellite communication system for establishing communication between at least two users, where each satellite of the system is capable of providing a plurality of transmission

beams and corresponding plurality of cells and users including a plurality of satationary/mobile subscribers, comprising:

satellite switching means comprising a first and second cell within a satellite positioned in earth orbit for initiating and sustaining communication between the users; and

means for handing-off a communication initiated through the first cell to the second cell during the communication.

According to a still further aspect of the present invention there is provided a non-geosynchronous satellite communication system for transmitting or receiving a communication from a user, where the satellite is capable of providing a plurality of transmission beams and corresponding plurality of cells, comprising:

a satellite positioned in earth orbit and having at least two cells, each cell comprising a communications channel;

link means for coupling the user to a first cell of the satellite; and

means coupled to the first cell for switching the communication to a second cell during the communication.

According to a still further aspect of the present invention there is provided a geographic frequency reuse communication system for transmitting or receiving a communication from a user comprising:

satellite switching means positioned in low-earth orbit; and

a plurality of means for coupling the user to said satellite to establish a communication link over which the communication is passed.

According to a still further aspect of the present invention there is provided a satellite frequency reuse communication system for transmitting or receiving a communication from a user, where the satellite is capable of providing a plurality of transmission beams and corresponding plurality of cells, comprising:

satellite switching means positioned in low-earth orbit; and

means for coupling the user to said satellite to establish a communication link over which the communication is passed.

According to a still further aspect of the present invention there is provided a non-geosynchronous satellite in non-geosynchronous orbit cellular communication system utilizing radio satellites for establishing communication among a plurality of users on the earth comprising:

a plurality of satellite assemblies adapted to be positioned in low-earth orbit, each of said plurality of satellite assemblies including cellular telephone switching means, a first communication link providing a multi-lobe cell pattern on the earth and coupling a signal for a cellular telephone user in the pattern to a satellite assembly, and a second communication link communicating with an adjacent satellite assembly, said switching means handing-off the user's signal among the lobe cell pattern and said links as said assemblies traverse their orbits.

According to a still further aspect of the present invention there is provided a satellite assembly for a cellular communication system utilizing a plurality of radio satellites for establishing communication among a plurality of users on the earth, said assembly adapted to be positioned in low-earth orbit and including:

cellular telephone switching means, a first communication link for providing a multi-lobe cell pattern on the earth for coupling a signal from a cellular telephone user in the pattern to said satellite assembly, and a second communication link providing communication to an adjacent radio satellite, said switching means coupled to said communication links and adapted to hand-off the user's signals among the lobes of the cell pattern and said communication links as said assembly traverses its orbit.

According to a still further aspect of the present

invention there is provided a non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit, a plurality of said satellite switching means being in each of a plurality of orbiting planes;

link means for coupling said users to at least one of said plurality of satellite switching means establishing a communication link between selected ones of said users via said satellite switching means;

first means for handing-off the communication link between at least two of said users from a first satellite switching means to a second satellite switching means in the same orbiting plane as said first satellite switching means; and

second means for handing-off the communication link between said users from said first satellite switching means to a third satellite switching means in an adjacent orbiting plane.

According to a still further aspect of the present invention there is provided a non-geosynchronous satellite communication system for communicating between at least two users, a called user and a calling user, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the users including a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means positioned in orbit;

link means for coupling said calling user via a first satellite switching means to said called user via a second satellite switching means establishing a communication link between said calling and called users;

and

means for handing-off said calling users link from said first satellite switching means to a third satellite switching means and for contemporaneously handing-off said communication link of said called subscriber from said second satellite switching means to a fourth satelling switching group.

According to a still further aspect of the present invention there is provided a non-geosynchronous secure satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobil subscribers, comprising:

a plurality of satellite switching means being positioned in orbit;

a plurality of subscriber units corresponding to said plurality of satellite switching means, each said subscriber unit for securely communicating with others of said subscriber units via said satellite switching means; and

means for handing-off the communication of said subscribers between said satellite switching means.

A satellite cellular telephone communication system may establish communication among a plurality of users. This communication system may include satellite switches positioned in low-earth orbit. Wireless communication links preferably couple the users to the satellite switches. The satellite switches may establish a communication link between selected ones of the users.

Each user's present location may be determined and the system may be periodically updated. Then the satellites may relay these locations to the proper ground-based data base for storage. When a mobile user places a call, the satellite which is in his spatial vicinity handles the call. When a mobile user is called, the satellite switches may route the call through the

appropriate satellites to the called user's current location. Other user-unique data may also be stored at these same data base storage sites.

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings wherein:

FIG. 1 is a layout diagram depicting the satellite switching system configuration of the present invention.

FIG. 2 is a block diagram depicting the interconnection of the satellite switching units with its association mobile users and interconnection to the public switched telephone network.

FIG. 3 is a projection of the areas served by a plane of cellular satellite switches about the earth.

FIG. 4 is a block diagram of a data base arrangement for a satellite cellular communication system.

Referring to FIG. 1, a satellite configuration for the satellite cellular telephone communication system is shown. In this configuration, a number of satellites are shown in low-earth orbit. A number of satellites are placed in each orbiting plane. There are several orbiting planes (3 through

8) as shown which are highly inclined in nature and provide switching coverage for the entire earth.

This satellite cellular structure is somewhat analogous to the present day cellular mobile telephone system. In that system, cellular sites are fixed and users are mobile. As a user travels from one cell site to another, his telephone call is handed off from one cellular switching unit to another.

In the present invention, users are relatively fixed at any given time while the satellites, which are the cells, are in continuous movement. With a hand-held or mobile mounted cellular telephone, connection to one of the satellite switches shown in FIG. 1 is made directly from the hand-held mobile mounted or remotely fixed telephone to one of the nearest satellite switches. Each satellite is moving about the earth. As the satellite which originally acted as the switching unit for a particular user leaves a cell of that switch, the user's call is "handed off" to the appropriate adjacent cell. Adjacent cells may be cells within one satellite or cells of other satellites located either in a particular orbiting plane or an adjacent orbiting plane. Users may "roam", but this roaming distance is relatively small compared to the traveling distance of the satellite switches.

Similar to the cellular mobile telephone system, the satellite cellular communication system provides spectral efficiency. This means that the same frequency may be simultaneously used by different satellite switches. Spectral efficiency is provided by the spatial diversity between the satellite switches and users.

The users may be located anywhere on a land mass, on the water or in the air at an altitude less than that of the low-earth orbiting satellites. For example, a person on one land mass could call a person on another land mass, a person on a boat or a person in an aircraft.

Low power hand-held mobile mounted or fixed radio telephones may be used in this system. The power requirement

is less than 10 watts with present technology.

In this system, each satellite shown is a switching unit. Current satellite communication systems act primarily as a relay station or "bent pipe". That is, they provide fixed point-to-point communications. In the present invention, a switching function is provided within each of the orbiting satellites.

As previously mentioned, each of the orbiting planes of satellites is highly inclined in the preferred embodiment of the invention. Orbiting satellite planes with lower inclination are also workable. However, the lower inclination requires more satellite switching units and/or higher orbiting altitudes to achieve whole earth coverage than does the highly inclined orbiting satellite configuration.

In a preferred embodiment, highly inclined orbit configuration, it was found that satisfactory earth coverage could be accomplished with forty-eight (48) low earth orbiting satellites. These satellites could be arranged in six (6) highly inclined orbiting planes, eight (8) satellites per plane. Other configurations could be used. Other lower inclined orbiting arrangements would require substantially more satellites in order to achieve the same coverage of the earth as highly inclined configuration.

Each satellite contains a satellite switching unit, suitable antennas 11 (helical antennas for up/down links and lenses for cross links, for example) and an unfolding array of solar cells 12 along with storage batteries (not shown) connected to the solar cells to provide power for the switching unit. The satellite buses or vehicles themselves are low-earth orbiting satellites such as those commercially available. The satellites are put into orbit by a launching vehicle. When in orbit, the solar cell array is opened and the switching unit thereby activated. The satellites are then individually brought on line via standard telemetry, tracking and control (TT&C) channels to form the network.

As shown in FIG. 1, a user A with a hand-held telephone

goes off-hook. This request for a channel is received by a particular satellite 1, as shown in FIG. 1. A frequency channel is assigned to the user and the caller's desired number is then routed through the system. Each satellite is a distributed local processor and determines how switching of the call is to occur. Satellite 1 switches the call to the appropriate cell contained either within its own cell complement or to the appropriate satellite cell complement. The path is determined by each satellite switching unit until the call is received by satellite 2. Satellite 2 then routes this call to the particular hand-held user B shown in FIG. 1.

Although two hand-held users are shown, the users may be on the water, in a moving vehicle, airborne or part of a PSTN where the link is through a gateway. Each satellite is a local processor. The system determines to which appropriate satellite or cell the call is to be switched. Each satellite determines an optimal path from itself to the next appropriate satellite. These determinations may be made based upon the office code portion of the telephone number of the called user.

Each satellite typically may project four (4) or more lobes onto the earth and contain four (4) or more corresponding cells for switching. These lobes of coverage are achieved via antennas (helical typically) with fixed beam widths appropriate to the number of lobes. Overlapping cells will be differentiated using present cellular techniques. These areas or lobes are shown in FIG. 3 for one particular plane of satellites about the earth. This figure depicts a high inclined orbiting satellite cellular switches. Each satellite determines the optimal path from it to the next satellite through which to route a particular call or data transmission. These satellite switches operate on data packets and therefore may transmit digital voice or data. Downlink and uplink data/digital voice is received on an FDM basis demodulated and then packetized for satellite-to-satellite communication.

FIG. 2 depicts the interconnection of a portion of one

plane of satellites. In addition, the connection of the satellite to the satellite's corresponding mobile users and to the public switched telephone network is shown. Three satellites are shown. Satellite 40, Satellite 50 and Satellite 60. Satellite 40 is connected to Satellite 50 by link i. Satellite 50 is connected to Satellite 60 by link i+1. Satellite 60 is connected to the next sequential satellite of the plane (not shown) via link i+2. Satellite 40 is connected to the next preceding satellite (not shown) via link i-1. Each plane of satellites forms a ring of connected satellites around the earth.

As previously mentioned, the drawing of FIG. 2 shows one plane of the satellites. In addition, each satellite is connected to one or more satellites in other orbiting planes. That is, each satellite is connected to a previous and next satellite in its orbiting plane and to one or more satellites in other orbiting planes.

The intersatellite links link i-1, link i, etc. may be implemented via data transmission on a microwave beam or via a laser beam. Existing technologies currently provide for such data transmission.

Connection between the satellites and its mobile users is achieved by beams j-1, and j+1, for example. These beams correspond to the lobes shown in FIG. 3 and to the switching cells mentioned above. These beams are achieved via the satellite up/down link antennas which provide communication to users via the users omnidirectional antenna. The limit on the number of users that a particular satellite may handle at one time depends on bandwidth allocated plus power available on the satellite. Typically this number may be 50,000 users per satellite.

Satellite 40 is shown connected to a trunk site or gateway 10 via beam j-1. Any satellite, such as Satellite 40, is capable of transmitting and receiving data from a gateway, such as gateway 10. This gateway link can be accomplished using the packetized data similar to the satellite-to-satellite links.

Gateway 10 includes units which interconnect to the public switched telephone network (PSTN) 20. All public switched telephone network users 30 are connected to the public switched telephone network 20. As a result of the satellite 40 being connected through gateway 10 to PSTN 20, a mobile user of the satellite cellular system which is connected directly via a beam to a satellite may transmit voice or data via the satellite structure (satellite-to-satellite via corresponding links), through gateway 10, through the public switched telephone network 20 to selected users of the PSTN 30 or vice versa.

Each satellite provides several data transmission beams. These data transmission beams project the lobes of coverage shown in FIG. 3 which depicts four beams. Each satellite projects four such lobes. As shown in FIG. 2, a satellite may use one or more of its beams to provide interface to a gateway. At least one beam is required for establishing a link between each gateway and the satellite. Typically a satellite links to only one gateway. One gateway provides sufficient trunking to interconnect a number of mobile users to the public switched telephone network 20.

Each satellite performs internal switching among its four beams or cells. This is analogous to intraoffice switching for conventional telecommunication systems.

The up/down linking arrangement between the satellites and its mobile users or gateways via the beams may transmit and receive data in the range of approximately 2.1 to 3.9 GHz, for example. The present technology and band availability makes this a preferred data transmission range. However, the scope of the present invention is not limited to data transmission exclusively within this range.

As previously mentioned, the data (digital voice or data) is transmitted in packet form. As a result, high-speed data transmission as well as voice data transmission may be accomplished via the satellite system. Data transmission rates, given the present available bandwidths, are a least 1200 baud. However, with extended bandwidth,

substantially higher data rates can be achieved by this system.

FIG. 4 depicts one satellite switching unit 100 directly connected to mobile users 120 via beam 102. Satellite 100 is connected to data base computer 110 via beam 104. Satellite 100 is also connected to data base computer 130 via beam 106. This connection may be direct via a beam 106 as shown in FIG. 4 or indirect through other satellites to data base computer 130.

A mobile user might "roam" or travel in a home area. The home area may be a city, such as New York, Los Angeles, etc. The data base computer 110 contains all the information relative to each of its mobile users. As long as a particular mobile user is operating within his home area, all the available information concerning that user is available at the local home area data base computer.

If, for example, a home area user in Los Angeles travels to New York City and attempts to use his satellite cellular telephone for communication, the data base computer in the user's new area, New York City, is not aware of the existence of that user. If data base computer 110 is the mobile user's home area, Los Angeles, data base computer 110 has all the information for this particular mobile user. As a result, the mobile user would not be allowed to place calls because he was not recognized by his home area's data base computer.

In order to overcome this problem, each mobile user is periodically interrogated by the system as to its location so when he goes off-hook, his call for service can be recognized and routed. However, since the data base of a particular user is stored in his home area data base computer via the satellite system, the satellite system first interrogates the home area to determine that he is no longer there and to obtain the user's switching information. When that determination is made, the new home area's data base computer can be updated to include this "roaming" user. As a result, this user is then allowed to originate and receive calls in

his new area. Because the satellite system interrogates the user's home data base computer to determine his location, the user can be found throughout the entire satellite system. Thus, the system provides the capability for finding "roaming" users and establishing communications with them.

To facilitate tracking of each mobile user, each mobile telephone provides a control signal which is periodically monitored so that when a subscriber originates a call, the nearest satellite can track him and through the satellite network interrogate his home data base computer to determine his pertinent customer information. The mobile telephone may automatically indicate to the satellite network a new location for updating the data base computer. This control signal allows the incoming calls of "roaming" users to be validated via satellite-to-satellite linking to the home area's data base computer.

Each satellite in the satellite cellular communication system is self-navigating. That is, it uses the Global Positioning Satellite system (GPS) or time and ephemeris data from which to compute its location information. In addition, from the fixed location of the Global Positioning Satellite system or other vehicle, each satellite can determine its position and alter its course accordingly to stay within its proper orbit while providing switching services.

Each satellite may switch a call intrasatellite (within the particular switching unit or cell) or may connect the call via a microwave or laser links (link i, i+1, etc.) to another satellite within its plane or out of plane (adjacent). Each satellite may distinguish a particular telephone number and determine whether that number is within its own calling area or the area of another satellite. If it is within the area of another satellite, the call is cross-linked to the next appropriate satellite or cell which makes the same determination until the satellite serving that telephone number is reached. That satellite down-links to the particular mobile user sought to be called. Due to this structure, the satellite network provides a distributed nodal

switching capability. Each satellite is a local switch for a particular area, but the area is constantly changing. Therefore, calls are handed-off as satellites move out of the range of a particular telephone user.

Various multiplexing techniques (i.e. FDMA, TDM CDMA, etc.) may be used to enhance the transmission capability between various satellites on the links as shown in FIG. 2.

Since the switching units of this system are orbiting the earth and relatively secure from tampering, this system provides the capability to support secure voice and data transmission via data encryption and decryption techniques commonly known in the art. Since the switching units enjoy the security of being hundreds of miles above the earth, the system also lends itself to military communication applications.

Although the current preferred embodiment of the invention has been illustrated, and that form described in detail, it will be readily apparent to those skilled in the art that various modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

The claims defining the invention are as follows:

1. A non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to at least one of said plurality of satellite switching means establishing a communication link between selected ones of said users via said satellite switching means; and

means for handing-off the communication link between said satellite switching means.

2. A satellite cellular communication system as claimed in claim 1, said satellite switching means including:

a plurality of satellite switching unit means positioned surrounding the earth in low-earth orbit; and

second link means for permitting multi-directional communication between one satellite switching unit means and any adjacent satellite switching unit means.

3. A satellite cellular communication system as claimed in claim 2, said second link means includir microwave communication means.

4. A satellite cellular communication system as claimed in claim 2, said second link means including laser communication means.

5. A satellite cellular communication system as claimed in claim 2, said satellite switching unit means including:

antenna means coupled to said plurality of users for establishing communication between said users and satellite switching unit means;

solar cell means for providing power for said satellite switching unit means; and

storage battery means connected to said solar cell means for storing said power.

6. A satellite cellular communication system as claimed in claim 1, said satellite switching means including a plurality of cell means coupled to one another, one said cell means operating to hand-off said established communication link between users to another one of said cell means.

7. A satellite cellular communication system as claimed in claim 1, wherein each of said users is connected to said link means by cellular telephone means.

8. A non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to said satellite switching means establishing a communication link between selected ones of said users via a said satellite switching means;

means for handing-off the communication link between said satellite switching means; and

said link means further coupling said satellite switching means to a public switched telephone network means, other ones of said users being connected to said public switched telephone network means, said public switched telephone network means operating to selectively connect users of said public switched telephone network means with users directly coupled to said satellite switching means via said link means.

9. A satellite cellular communication system as claimed in claim 8, wherein there is further included means for connecting said link means to said public switched telephone network means, said means for connecting providing gateway facility services between said satellite switching means and said public switched telephone network

means.

10. A non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to said satellite switching means establishing a communication link between selected ones of said users via said satellite switching means;

means for handing-off the communication link between said satellite switching means; and

data base means coupled to said satellite switching means via said link means, said data base means for storing and transmitting switching information describing each of said plurality of users.

11. A non-geosynchronous satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit;

link means for coupling at least one of said users to said satellite switching means establishing a communication link between selected ones of said users via said satellite switching means;

means for handing-off the communication link between said satellite switching means;

cellular telephone means having a control signal for connecting each of said users to said satellite switching means via said link means;

data base means coupled to said satellite switching means via said link means, said data base means for storing and transmitting switching information describing each of said plurality of users; and

said satellite switching means operating in response to said control signal of each of said user's cellular telephone means to update said data base means with a present location of each user.

12. A satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in low-earth orbit about the earth;

link means for coupling at least one of said users to said satellite switching means establishing a communication link between selected ones of said users via said satellite switching means; and

means for handing-off the communication link by the satellite switching means.

13. A satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in non-geosynchronous orbit;

first link means for coupling said users to said satellite switching means establishing a communication link between selected ones of said users via at least one of said plurality of satellite switching means;

means for handing-off the communication link between said satellite switching means; and

second link means for permitting multidirectional communication between one of said plurality of satellite

switching means of a first satellite and any adjacent one of said plurality of satellite switching means of a second satellite.

14. A satellite cellular communications system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for use in non-geosynchronous orbit;

link means for coupling said users to said satellite switching means establishing a communications link between selected ones of said users via at least one of said plurality of satellite switching means; and

means for handing-off the communications link between said satellite switching means.

15. A satellite cellular communication system as claimed in claim 14, wherein each said satellite switching means includes distributed local processor means for determining switching of a call between said users.

16. A satellite cellular communication system as claimed in claim 14, wherein each said satellite switching means includes distributed nodal switching means.

17. A method of communicating in a non-geosynchronous satellite cellular system, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile subscribers, comprising:

a subscriber communicating with a satellite; and

handing-off that ongoing communication to another satellite.

18. A method of communicating in a non-geosynchronous satellite cellular system, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile

subscribers, comprising:

a subscriber communicating with a satellite; and

contemporaneously terminating the communication via the communicating satellite and re-establishing the communication via another satellite, whereby the continuity of the communication is substantially maintained.

19. A satellite cellular system, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile subscribers, comprising:

means for a subscriber communicating with a satellite in non-geosynchronous orbit; and

means for handing-off that ongoing communication to another satellite in non-geosynchronous orbit.

20. A cellular satellite for use in a satellite cellular system in non-geosynchronous orbit, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and where there is further included a plurality of stationary/mobile subscribers, comprising:

means for receiving at a satellite communication; and

means for handing-off that ongoing communication to another satellite.

21. A non-geosynchronous satellite communication system for establishing communication between at least two users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and users including a plurality of stationary/mobile subscribers, comprising:

satellite switching means comprising a first and second satellite positioned in earth orbit for initiating and sustaining communication between the users; and

means for handing-off a communication initiated through the first satellite to the second satellite during the communication.

22. A non-geosynchronous satellite communication system

for establishing communication between at least two users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and users including a plurality of stationary/mobile subscribers, comprising:

satellite switching means comprising a first and second cell within a satellite positioned in earth orbit for initiating and sustaining communication between the users; and

means for handing-off a communication initiated through the first cell to the second cell during the communication.

23. A non-geosynchronous satellite communication system for transmitting or receiving a communication from a user, where the satellite is capable of providing a plurality of transmission beams and corresponding plurality of cells, comprising:

a satellite positioned in earth orbit and having at least two cells, each cell comprising a communications channel;

link means for coupling the user to a first cell of the satellite; and

means coupled to the first cell for switching the communication to a second cell during the communication.

24. A system as set forth in claim 23, wherein the system comprises at least two satellites, and the switching occurs between the two satellites.

25. A geographic frequency reuse communication system for transmitting or receiving a communication from a user comprising:

satellite switching means positioned in low-earth orbit; and

a plurality of means for coupling the user to said satellite to establish a communication link over which the communication is passed.

26. A satellite frequency reuse communication system for transmitting or receiving a communication from a user, where the satellite is capable of providing a plurality of

transmission beams and corresponding plurality of cells, comprising:

satellite switching means positioned in low-earth orbit; and

means for coupling the user to said satellite to establish a communication link over which the communication is passed.

27. In a satellite cellular communication system utilizing radio satellites in non-geosynchronous orbit for establishing communication among a plurality of users on the earth comprising:

a plurality of satellite assemblies adapted to be positioned in low-earth orbit, each of said plurality of satellite assemblies including cellular telephone switching means, a first communication link providing a multi-lobe cell pattern on the earth and coupling a signal for a cellular telephone user in the pattern to a satellite assembly, and a second communication link communicating with an adjacent satellite assembly, said switching means handing-off the user's signal among the lobe cell pattern and said links as said assemblies traverse their orbits.

28. A satellite assembly for a cellular communication system utilizing a plurality of radio satellites for establishing communication among a plurality of users on the earth, said assembly adapted to be positioned in low-earth orbit and including:

cellular telephone switching means, a first communication link for providing a multi-lobe cell pattern on the earth for coupling a signal from a cellular telephone user in the pattern to said satellite assembly, and a second communication link providing communication to an adjacent radio satellite, said switching means coupled to said communication links and adapted to hand-off the user's signals among the lobes of the cell pattern and said communication links as said assembly traverses its orbit.

29. A non-geosynchronous satellite cellular

communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means for being positioned in orbit, a plurality of said satellite switching means being in each of a plurality of orbiting planes;

link means for coupling said users to at least one of said plurality of satellite switching means establishing a communication link between selected ones of said users via said satellite switching means;

first means for handing-off the communication link between at least two of said users from a first satellite switching means to a second satellite switching means in the same orbiting plane as said first satellite switching means; and

second means for handing-off the communication link between said users from said first satellite switching means to a third satellite switching means in an adjacent orbiting plane.

30. A satellite cellular communication system as claimed in claim 29, wherein there is further included:

third means for handing-off the communication link from said first satellite switching means to a fourth satellite switching means moving in an opposite direction from said first satellite switching means and being in an adjacent orbiting plane.

31. A non-geosynchronous satellite communication system for communicating between at least two users, a called user and a calling user, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the users including a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means positioned

in orbit;

link means for coupling said calling user via a first satellite switching means to said called user via a second satellite switching means establishing a communication link between said calling and called users; and

means for handing-off said calling users link from said first satellite switching means to a third satellite switching means and for contemporaneously handing-off said communication link of said called subscriber from said second satellite switching means to a fourth satellite switching group.

32. A non-geosynchronous secure satellite cellular communication system for communicating among a plurality of users, where each satellite of the system is capable of providing a plurality of transmission beams and corresponding plurality of cells and the plurality of users includes a plurality of stationary/mobile subscribers, comprising:

a plurality of satellite switching means being positioned in orbit;

a plurality of subscriber units corresponding to said plurality of satellite switching means, each said subscriber unit for securely communicating with others of said subscriber units via said satellite switching means; and

means for handing-off the communication of said subscribers between said satellite switching means.

33. A satellite cellular communication system, substantially as hereinbefore described and as shown in the accompanying drawings.

DATED: 3 July, 1992
PHILLIPS ORMONDE & FITZPATRICK
Attorneys For:
MOTOROLA, INC.

David B Fitzpatrick

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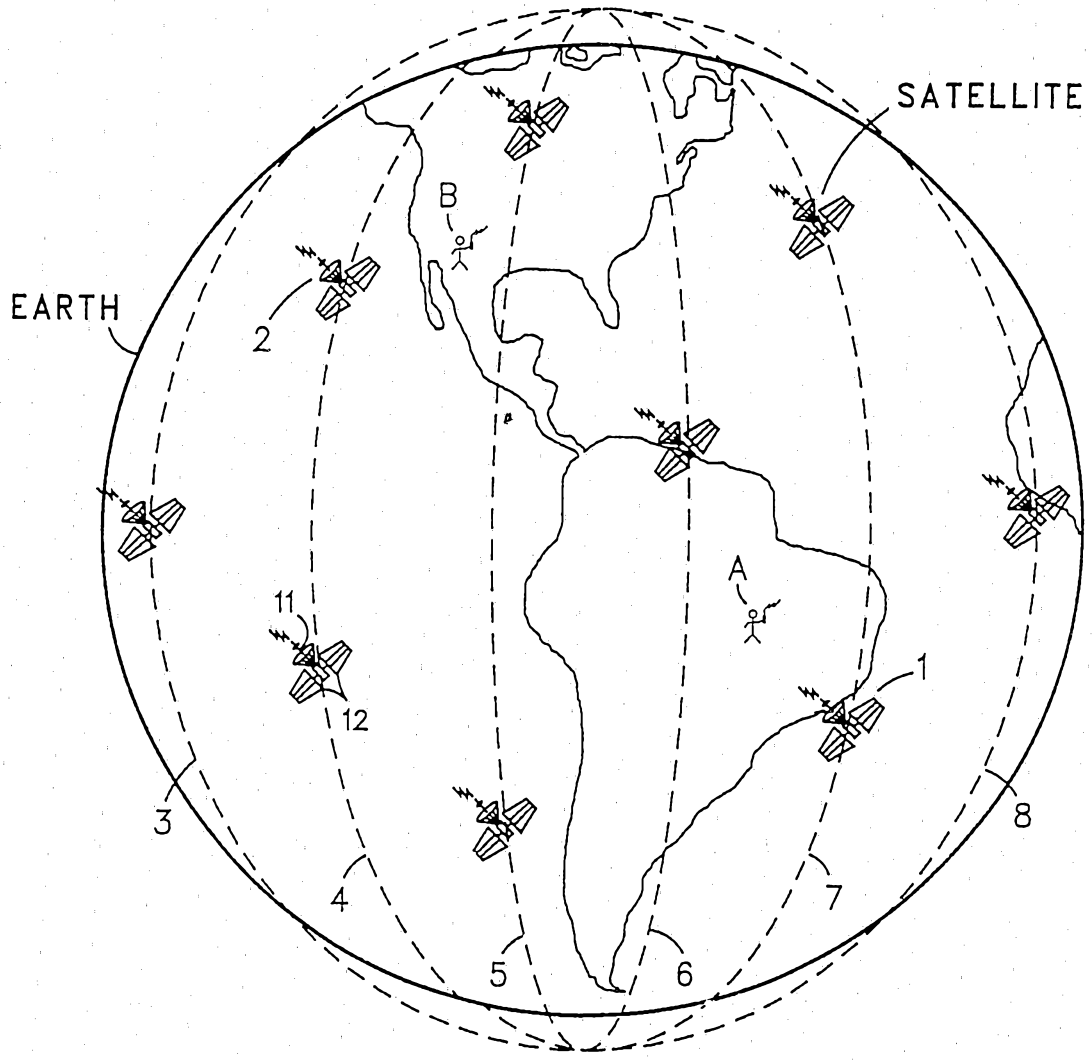
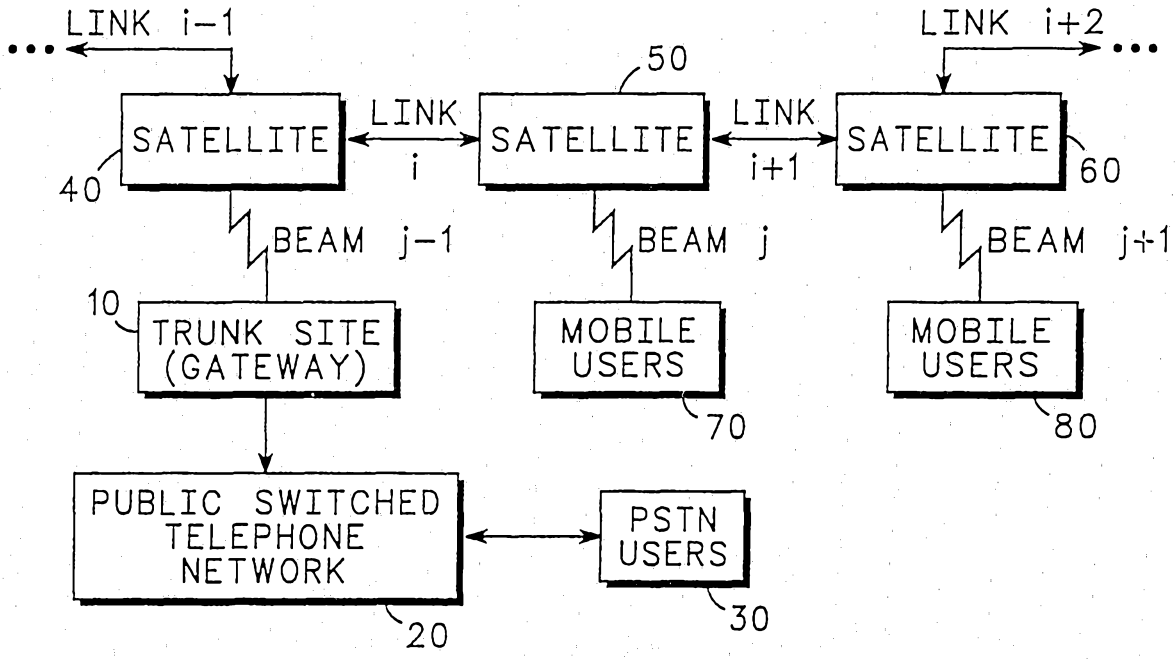


FIG. 1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LINK
i
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LINK
i+1
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60
BEAM j-1
BEAM j
BEAM j+1
10
TRUNK SITE
(GATEWAY)
MOBILE
USERS
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PUBLIC SWITCHED
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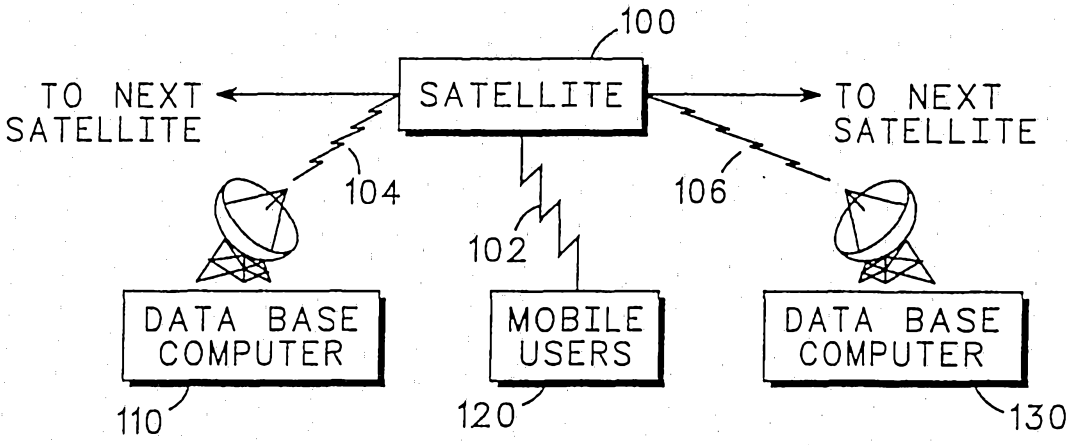
FIG. 2

FIG. 4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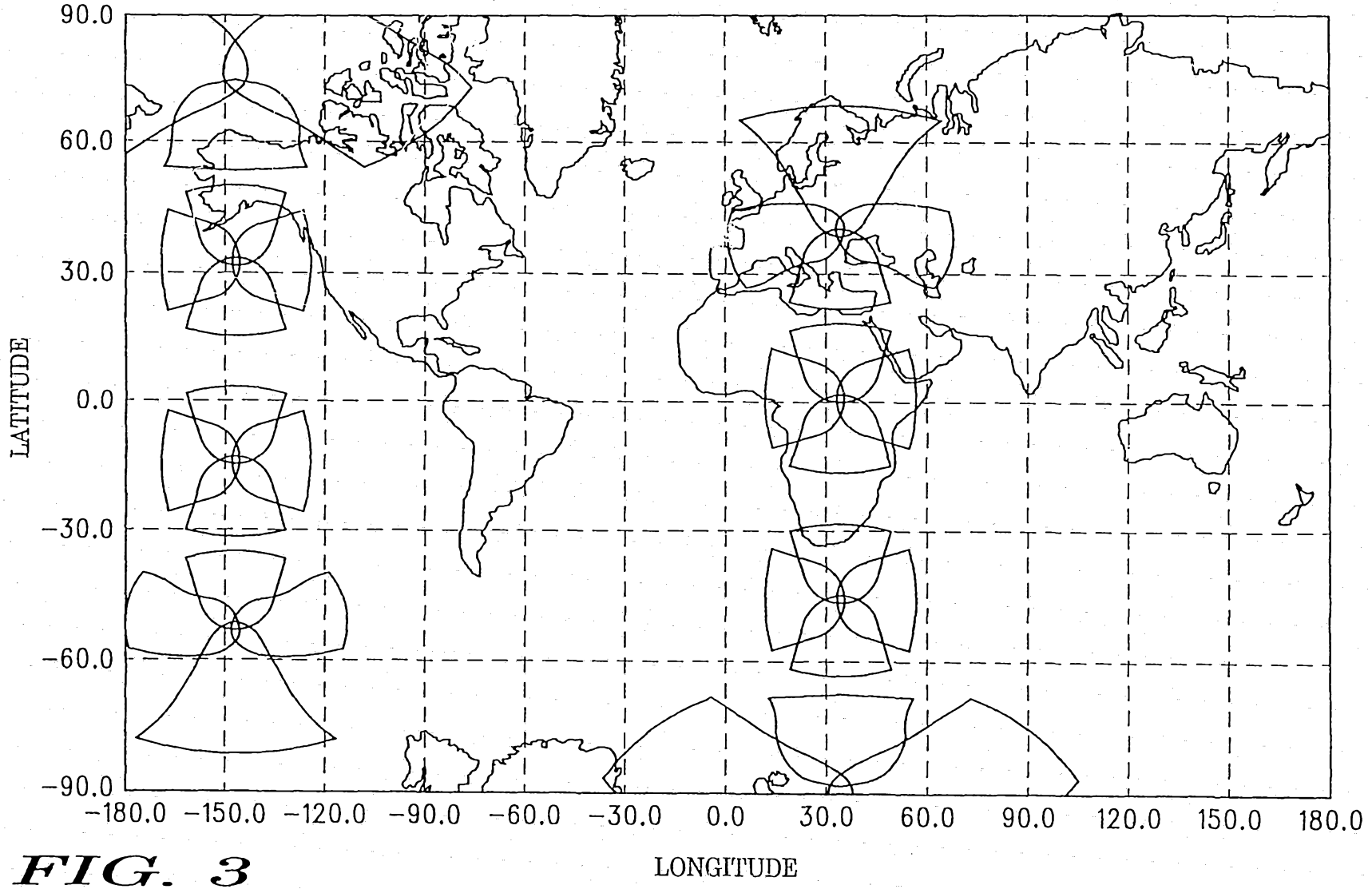
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-180.0 -150.0 -120.0 -90.0 -60.0 -30.0 0.0 30.0 60.0 90.0 120.0 150.0 180.0
LONGITUDE

FIG. 3