

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 August 2002 (15.08.2002)

PCT

(10) International Publication Number
WO 02/063895 A1

(51) International Patent Classification⁷: H04Q 7/20, 7/32, 7/38

(74) Agent: GROMADA, James, A.; Katten Muchin Zavis, Patent Administrator, 525 West Monroe Street, Suite 1600, Chicago, IL 60661-3693 (US).

(21) International Application Number: PCT/US02/02759

(22) International Filing Date: 1 February 2002 (01.02.2002)

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/775,510 5 February 2001 (05.02.2001) US
60/290,682 15 March 2001 (15.03.2001) US
09/889,927 9 July 2001 (09.07.2001) US

(71) Applicant (for all designated States except US): SOMA NETWORKS, INC. [US/US]; Suite 2000, 185 Berry Street, San Francisco, CA 94107 (US).

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

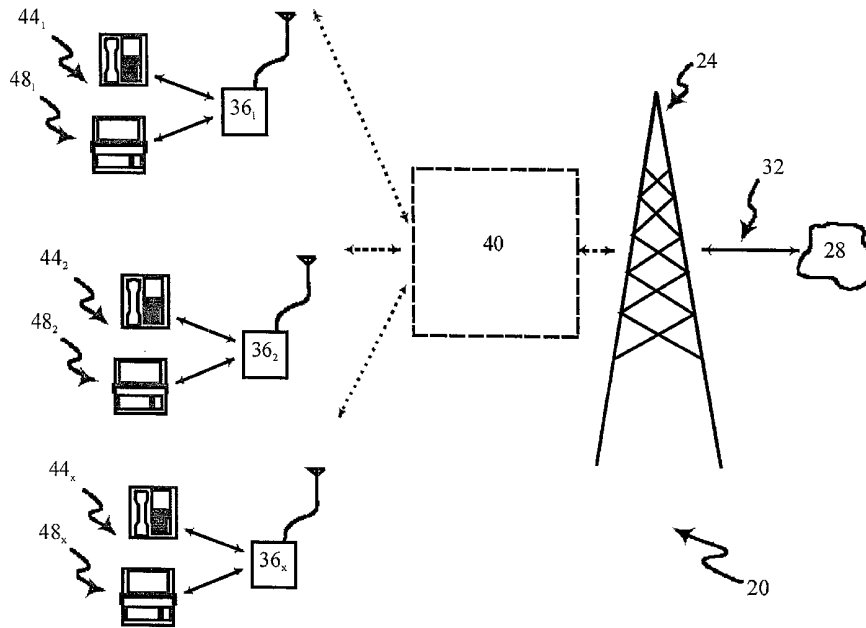
(72) Inventor; and

(75) Inventor/Applicant (for US only): HEINZMANN, Fred, J. [US/US]; 820 Vista Grande Avenue, Los Altos, CA 94024 (US).

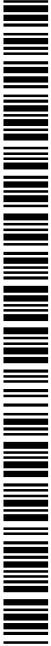
Published:
— with international search report

[Continued on next page]

(54) Title: EXTERNAL ANTENNA FOR A WIRELESS LOCAL LOOP SYSTEM



(57) Abstract: A wireless local loop system (fig. 1) is provided that includes a wireless base station (24) that communicates with a subscriber (44) station via a wireless link. The wireless link can carry a voice service, such as telephone calls, or a data service, such as internet browsing. The subscriber station is attached to an externally mounted steerable antenna. The antenna can be oriented in a desired direction during the transception of a voice or data service. A method of transceiving between a wireless local loop subscriber station and a wireless local loop base station is also provided.



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EXTERNAL ANTENNA FOR A WIRELESS LOCAL LOOP SYSTEM

FIELD OF THE INVENTION

The present invention relates to telecommunication systems and, more specifically, to a steerable subscriber station antenna, for a wireless local loop system, that is typically mounted on the exterior of the subscriber premises.

BACKGROUND OF THE INVENTION

Various forms of modern wireless communications systems are well known. For example, cellular wireless voice services are now widely deployed, and technology improvements are expected to enhance and expand cellular wireless services and capabilities.

Wireless local loop (WLL) systems are also expected to become a viable alternative to the wired local loop telephone services offered by the existing local telephone companies throughout North America and other places. WLL systems typically include a network of wireless base stations, each serving a plurality of subscribers via radio. In turn, each subscriber possesses a subscriber station that supports voice services (e.g. telephone) and/or data services (e.g. internet) using wireless communication with one or more of the base stations.

Attempts have been made to implement WLL systems. In general, these systems have either failed or not enjoyed broad penetration. One system that failed was the IONICA™ system implemented in United Kingdom. The IONICA™ system (explained in some detail in U.S. patent 5,952,966 to Smith) required an aimed antenna mounted to the exterior of the subscriber's premises and connected via a cable to the subscriber station within the subscriber premises. These external antennas needed to be installed by professional installers, often at significant expense, as the IONICA system required the subscriber antenna to be aimed towards the base station best suited to service the subscriber.

Such aimed external antennas suffered the additional problem that, as new base stations were added to the network to provide additional capacity, existing subscribers needed to have their antenna re-aimed by the professional installers in order to redirect the subscriber's antenna to a new base station, thus increasing the expense of operating the system and causing frustration to the subscriber as they waited for the professional installer to make the adjustments. It has been suggested that IONICA™ failed, at least in part, because of the problems associated with

unwieldy external antennas.

In general, more recent WLL systems still rely on aimed external antennas. For example, the so-called "Project Angel" system promulgated by AT&T used an aimed external antenna. While these more recent systems have overcome some of the other limitations of IONICA™, the need for careful aiming of an external antenna can still be a barrier for some subscribers desiring access to WLL services.

Steerable antennas are also known. For example, U.S. Patent 4,700,197 to Milne teaches an adaptive array antenna that is adapted for use in mobile terminals that communicate with satellite communication systems. One problem with Milne is that it teaches the use of over a dozen parasitic elements that require complex controls to steer the antenna, and overall adding extra cost and/or complexity to the mobile terminal, thus making it generally unsuitable for use in a WLL system.

U.S. Patent 6,037,905 to Koscica teaches a steerable antenna having a plurality of radiating elements that are comprised of a series of diodes connected in series with conductors having a length that is a fraction of the wavelength of the design frequency. A basic assumption behind Koscica is that the radiating elements (active or passive) are broken into lengths much smaller than a wavelength in order to make them electrically transparent. However, if this design was applied to common cellular telephone applications or a WLL system, the performance of this antenna would be poor because of the losses due to the plurality of diodes.

U.S. Patent 6,034,638 to Thiel teaches a steerable antenna for use in mobile telephones. Specifically, Thiel teaches an antenna having four equally spaced monopole elements mounted in a symmetric array on the outer surface of a solid cylinder structure. The cylinder has a high dielectric constant, and extends from a conductive ground plane. The monopole elements can be switched by switching elements so that one or more is active, with the others acting as parasitic directors/reflectors being connected to ground, or left in an open circuit to be effectively transparent. One problem with Thiel is that the mounting of the monopole elements within the solid cylinder structure results in an antenna that may be physically robust for the abuse to which a mobile telephone can be subjected, but is unnecessary and/or overly expensive when applied to a WLL subscriber station. Furthermore, Thiel teaches the switching of the elements in order to reduce the exposure of the subscriber to electromagnetic radiation when the cellular telephone is placed near the subscriber's head, a constraint that is not of concern in a WLL subscriber station.

Also, Thiel teaches the switching of the driven elements, yet it is believed that switching in this manner can cause unacceptable performance loss in a WLL subscriber station. In general, the configuration of the antenna in Thiel and the method of switching the antenna in Thiel is directed to mobile applications, and is thus unsuitable for fixed wireless applications.

The above problems are mitigated or obviated, at least in part, by the antenna taught in Applicant's copending application entitled "Wireless Local Loop Antenna" filed in the United States Patent and Trademark Office on February 5, 2001, and assigned Application Number 09/775,510, the contents of which are incorporated herein by reference, and from which the present application claims priority. It has been determined that in certain situations, it can be desired to have additional transception quality to that that can be offered by an internal antenna. It is therefore desired to provide an antenna for a WLL system that provides improved transception-quality, while reducing the need for a professional installer of the antenna.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel antenna for WLL systems that obviates or mitigates at least one of the above-identified disadvantages of the prior art.

In a first aspect of the invention, there is provided wireless local loop system for carrying at least one subscriber service between a network and a subscriber terminal via a wireless link, said system comprising:

at least one base station interconnecting said network and said wireless link, said base station operable to transceive said service over said link; and

a subscriber station interconnecting said subscriber terminal and said wireless link, said subscriber station being connected by a wired-link to a steerable antenna that is mounted externally to said subscriber station and is operable to be oriented in a direction having a desired transception-quality of said service over said link.

The subscriber service is typically either a voice service (e.g. telephone calls) and/or a data service (e.g. web-browsing or email) but other types of services are within the scope of the invention. By the same token, the network is a network respective to the type of service, such as a public switched telephone network, private switched telephone network and/or a packet data network.

The subscriber terminal can be any terminal operable to carry the subscriber service(s),

such as telephone, computer, intelligent device, personal digital assistant or the like.

The antenna is typically electrically steerable and mounted exterior of the subscriber station housing, for example on the exterior of the subscriber premises, and includes a plurality of directional antennas that are oriented in different sectors to each other. Each directional antenna is switchable such that the antenna transceives the radio link in a desired direction.

The transception-quality can be measured using any suitable metric, such as signal-to-noise ratio, bit error rate, frame error rate, bit rate, power level and frame rate of the wireless link. The desired transception-quality can be based on the orientation requiring the least emitted power level from the subscriber station.

In another aspect of the present invention, there is provided a method of orienting a steerable antenna connected to a wireless local loop subscriber station, comprising the steps of:

- determining an appropriate time to orient said antenna;
- scanning said steerable antenna in a given orientation and measuring a transception-quality of a wireless link in said given orientation;
- repeating said scanning step until a desired number of orientations have been scanned;
- and
- orienting said antenna towards the one said orientation that has a desired transception-quality for a subscriber service transmitted over said link.

A wireless local loop system is provided that includes a wireless base station that communicates with a subscriber station via a wireless link. The wireless link can carry a voice service, such as telephone calls, or a data service, such as internet browsing. The subscriber station includes a steerable antenna that can be mounted to the outside of the subscriber's premises, or any other location desirable to the subscriber. A presently preferred steerable antenna for use with the subscriber station includes a plurality of directional antenna elements each oriented in a different direction to the other.

The transception can be effected in a desired direction. By allowing the antenna to be dynamically steerable, the varying transception-qualities of the link, (caused by, for example, moving multipath objects or fading) between the subscriber station and the base station can be compensated for in a dynamic fashion. It is believed the present invention can, in certain circumstances, obviate the need for the professional installation and manual orientation of a directional external, as the subscriber can mount the antenna himself or herself without being

concerned whether the antenna is oriented in the proper direction and/or without requiring special cables and/or cables of fixed lengths. This also means that as additional base stations are added to the wireless local loop system, it is unnecessary to reorient the subscriber's antenna, thus saving additional cost and service interruptions of having a professional installer re-attend at the subscriber premises to reorient the antenna.

According to another aspect of the present invention, there is provided a subscriber station for a wireless local loop system that carries at least one subscriber service between a network and a subscriber terminal, said system including at least one base station interconnecting said network and a wireless link, said base station operable to transceive said service over said link, said subscriber station comprising:

a microprocessor-assembly interconnecting said subscriber terminal and a modem, said microprocessor-assembly for processing said subscriber service, said modem for modulating and demodulating said service;

a radio connected to said modem and for converting said service for transception over said wireless link; and

a connection means for attaching a steerable antenna to said radio, said steerable antenna operable to be oriented in a direction that achieves a desired transception-quality of said service over said link.

According to yet another aspect of the present invention, there is provided an antenna for a wireless local loop subscriber station comprising:

a connecting means for attaching said antenna to a radio of said subscriber station; and

a plurality of directional antennas each defining a different sector of coverage for said antenna, each of said directional antennas being switchable in relation to each other such that said antenna transceives a radio link in said direction.

According to yet another aspect of the present invention, there is provided an antenna for a wireless local loop subscriber station comprising:

a connecting means for attaching said antenna to a radio of said subscriber station, said connecting means carrying control signals and radio link signals between said subscriber station and said antenna and carrying power for operating said antenna from said subscriber station;

a plurality of directional antennas each defining a different sector of coverage for said antenna;

switching means to select one or more of said directional antennas for transceiving a radio link signal;

a low noise amplifier to amplify radio link signals received by said one or more directional antennas;

a power amplifier to amplify radio signals from said subscriber station radio for transmission on said radio link by said one or more directional antennas;

an adjustable attenuator to attenuate radio link signals carried over said connecting means;

a signal power level detector; and

a controller element operable to:

(a) exchange control signals between said antenna and said subscriber station over said connecting means;

(b) separate said radio link signals from said control signals

(c) separate said power for said antenna;

(d) report the power level detected by said signal power level detector and the adjustment of said adjustable attenuator to said subscriber station in a control signal;

(e) respond to control signals received from said subscriber station to configure said switching means to select one or more of said directional antennas; and

(f) respond to control signals received from said subscriber station to adjust said adjustable attenuator to a desired level.

The present invention provides a versatile, good performance antenna which can be installed by a typical subscriber without the need for a professional installer. In one embodiment, cable lengths and qualities are automatically compensated for and a single cable carries the control signals, power for the antenna and radio signals between the subscriber station and the antenna. In another embodiment, radio signals are sent over the connecting means as intermediate frequency signals which mitigates cable losses of the signals. Uplink signals are modulated at the antenna to the required RF frequency for transmission and received RF downlink signals are demodulated at the antenna and sent over the connecting means as IF frequency signals.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Figure 1 shows a schematic representation of a wireless local loop system;

Figure 2 shows a schematic representation of a base station in the system of Figure 1;

Figure 3 shows a schematic representation of a subscriber station shown in the system of Figure 1;

Figure 4 shows a perspective view of an antenna in the subscriber station of Figure 3;

Figure 5 shows a front view of the antenna shown in Figure 4;

Figure 6 shows a top view of the antenna shown in Figure 4;

Figure 7 shows the top schematic view of the antenna of Figure 4 shown between the base station of Figure 1 and a multipath object;

Figure 8 shows a flowchart of a method of operating the antenna of Figure 4;

Figure 9 shows the schematic view of Figure 7 wherein a first of four sectors of the antenna is scanned;

Figure 10 shows the schematic view of Figure 7 wherein a second of four sectors of the antenna is scanned;

Figure 11 shows the schematic view of Figure 7 wherein a third of four sectors of the antenna is scanned;

Figure 12 shows the schematic view of Figure 7 wherein a fourth of four sectors of the antenna is scanned;

Figure 13 shows the schematic view of Figure 7 wherein two of the four sectors are scanned;

Figure 14 shows a block diagram of another embodiment of the present invention; and

Figure 15 shows a block diagram of yet another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figure 1, a wireless local loop system is indicated generally at 20. System 20 includes a radio base station 24 that connects, through appropriate gateways (not shown), to communication networks 28 via one or more backhauls 32. Examples of networks 28 and include the public switched telephone network (PSTN) and/or packet data networks, such

as the Internet. Backhaul 32 can be any known type of backhaul link between radio base station 24 and network 28, such as a T1, T3, OC1 or a microwave link.

As will be explained in greater detail below, system 20 can have additional base stations 24, as desired, and that communications between multiple base stations 24 and subscriber stations 36 can be managed using known handoff techniques. Additionally, base station 24 can be multi-sectored, each sector being defined by directional antennas, as is known by those of skill in the art.

A wireless link 40, composed of various communications channels, can be established between base station 24 and one or more of a plurality of subscriber stations 36. Utilizing one or more communication channels, wireless link 40 allows information to be transferred between base station 24 and respective subscriber stations 36, as needed. In a present embodiment, the radio-communication multiple access technique employed over wireless link 40 is CDMA, however, other types of techniques and/or protocols, such as GSM, FDMA, OFDM, or TDMA are also within the scope of the invention. In a present embodiment, data transmitted on wireless link 40 is formed into packets and the implementation/type of packet communication employed is not particularly limited, and can include IP (with TCP or UDP) and/or modifications thereof or any other packet implementation as will occur to those of skill in the art. While the present embodiment is directed to digitally-based radio communications, it will be understood that the present invention can be modified to accommodate analog based radio communications, such as that found in analog cellular telephone networks.

In a presently preferred embodiment, each subscriber station 36 is fixed within a subscriber's premises. However, it is also contemplated that the present invention can be applicable, with appropriate modifications to mobile and/or nomadic subscriber stations. Each subscriber station 36 is operable to connect to one or more voice terminals 44 (e.g. a telephone) to provide voice services, and to connect to one or more data terminals 48 (e.g. a computer) to provide general data services. It will thus be apparent that each voice terminal 44 and its respective data terminal 48 can be separate devices or can be combined into a single intelligent device, such as a telephone with a built-in web browser or any other intelligent device that is operable to process both voice and data. In general, each voice terminal 44 is operable to process voice telephone calls carried over a PSTN portion of network 28, while data terminal 48 is operable to process general data applications carried over a packet switched data network

portion of network 28. It is to be understood that in other embodiments of the invention, subscriber station 36 and system 20 can be modified to provide different types of services, or to only provide voice or data services.

Figure 2 shows base station 24 in greater detail. Base station 24 comprises an antenna 100 for receiving and transmitting radio-communications over wireless link 40. In turn, antenna 100 is connected, via any suitable connecting means, to a radio 104 and a modem 108. Modem 108 is connected to a microprocessor-router assembly 112. A suitable microprocessor would be a SPARC processor system manufactured by SUN Microsystems. It will be understood that assembly 112 can include multiple microprocessors, as desired. The router within microprocessor-router assembly 112 is connected to backhaul 32 in any suitable manner, which in turn connects base station 24 to network 28 via appropriate gateways (not shown). Other suitable configurations of base station 24 will occur to those of skill in the art.

Referring now to Figure 3, subscriber station 36 is shown in greater detail. Subscriber station 36 is attached to a steerable antenna 200 for receiving and/or transmitting (“transceiving”) radio-communications over wireless link 40. Station 36 and antenna 200 are connected via a wired-link 202, that carries power signals, antenna control signals, and signals transceived over wireless link 40 between subscriber station 36 and antenna 200.

In turn, wired link 202 is connected to a radio 204 within subscriber station 36 and to antenna control sources, such as microprocessor-assembly 212, and a power supply (not shown). Radio 204 then connects to a modem 208, which in turn is connected to microprocessor-assembly 212.

As is discussed in more detail below, typically antenna 200 is mounted distal to subscriber station 36. For external applications, antenna 200 can be mounted substantially vertically outside of the subscriber’s premises, either directly to the premises or proximal thereto. While not shown herein, a protective radome, such as a plastic cylinder, is also typically included to protect antenna 200 from weather elements, while still allowing transception over wireless link 40. It is also contemplated that antenna 200 can be mounted within a subscriber’s premises, for example in an attic, if desired.

Antenna 200 is mounted any suitable mechanical hardware as will occur to those of skill in the art, although preferably as part of a kit mechanical hardware is provided that would allow a subscriber to mount the antenna him or herself, without the need for a professional installer.

While not a critical feature of the invention, in order to further simplify installation wired-link 202 is preferably a single piece of dual conductor cable, such as coaxial cable used in CATV installations. In such circumstances, subscriber station 36 and antenna 200 are designed such that power signals, antenna control signals, and transceived signals from/to wireless link 40 are all carried over different frequencies within the coaxial cable, with appropriate circuitry at each end of wired-link 202 to differentiate between each signal carried on link 202. However, it is also contemplated that wired-link 202 can include separate cables for one or more signals.

The remaining components of subscriber station 36 are housed within a chassis. For safety reasons, such a housing can be configured to restrict access by the subscriber to the components of subscriber station 36.

Microprocessor-assembly 212 which can include, for example, a StrongARM processor manufactured by Intel, performs a variety of functions, including implementing A/D-D/A conversion, voice codecs, filters, encoders, data compressors and/or decompressors for packet assembly/disassembly. As seen in Figure 3, microprocessor-assembly 212 interconnects modem 208 and a pair of ports 214, 216. Accordingly, microprocessor-assembly 212 is operable to process voice services for voice terminal 44 (connected to port 214), and data services for data terminal 48 (connected to port 216).

The type of steerable antenna 200 used in association with subscriber station 36 is not particularly limited and a present embodiment of a steerable antenna 200 for use in subscriber station 36 is shown in Figures 4-6. Antenna 200 comprises a plurality of elements 258a, 258b, 258c and 258d. In the presently preferred embodiment, antenna 200 is used within the spectrum of from about 1850 Megahertz ("MHz") to about 1990 MHz (referred to herein as the "PCS band"). Each element 258 is sized and configured to be responsive within the PCS band. More particularly, the frequency range of from about 1850 MHz to about 1910 MHz is reserved for transmitting from subscriber station 36 to base station 24 (i.e. the "uplink" or "forward link") over wireless link 40. Similarly, the frequency range from about 1930 MHz to about 1990 MHz is reserved for receiving transmissions from base station 24 to subscriber station 36 (i.e. the "downlink" or "reverse link") over wireless link 40, with the remaining frequency range of about 1910 MHz to about 1930 MHz serving as a guard-band between the uplink and downlink. It is to be understood, however, that antenna 200 can be designed to operate in any frequency range, as desired and, for example, antenna 200 can also be constructed for operation in the

MMDS and/or WCS bands.

In the present embodiment, each element 258 is effectively a directional antenna, oriented in different directions in relation to each other. In the embodiment of Figure 4-6, each element 258 is oriented on antenna 200 at an angle of ninety degrees to the adjacent elements 258, thereby providing four directions, or sectors, of potential coverage, with the availability of additional coverage patterns by using two or more elements 258 in combination. Thus, the base of each element 258 is defined by one of the four sides of a substantially square tubular substrate 262. Substrate 262 is preferably hollow, made from a thin gauge of aluminum that is rigid enough to support each element 258, yet light enough to reduce the overall weight of antenna 200 for considerations such as reduced materials cost, ease of assembly, ease of mounting, and/or ease of transport.

Each element 258 is characterized by a first sub-element 264₁ and a second sub-element 264₂. As shown in Figures 4-6, elements 258a, 258b, 258c and 258d each have a first sub-element 264a₁, 264b₁, 264c₁, and 264d₁ and a second sub-element 264a₂, 264b₂, 264c₂ and 264d₂, respectively.

Each sub-element 264 is characterized by an inner patch 270, adjacent to substrate 262 and an outer patch 274. Each patch 270, 274 is substantially the same octagonal shape and of substantially the same size. A fastener-and-spacer assembly 276 is used to mechanically secure each inner patch 270 and outer patch 274 to substrate 262. As shown in the Figures, first sub-elements 264a₁, 264b₁, 264c₁, and 264d₁ each have an inner patch 270a₁, 270b₁, 270c₁, and 270d₁ and an outer patch 274a₁, 274b₁, 274c₁, and 274d₁, respectively. By the same token, second sub-elements 264a₂, 264b₂, 264c₂ and 264d₂ each have an inner patch 270a₂, 270b₂, 270c₂, and 270d₂, and an outer patch 274a₂, 274b₂, 274c₂, and 274d₂, respectively.

Each element 258 also includes a trace 278 that connects at one end to a switching means 282 resident on a cap portion 286, best seen in Figure 6, that closes tubular substrate 262. Each trace 278 runs along the surface of cap portion 286 to its periphery, at which point each trace 278 extends perpendicularly to cap portion 286 so that each trace 278 runs parallel to its respective element 258. As best seen in Figures 4 and 5, each trace 278 runs along its respective element 258, interconnecting both inner patches 270 of the respective element 258 along the path of trace 278. Traces 278 and sub-elements 264 are all preferably made from aluminum, but any suitable conducting material for antennas can be used, for example traces 278 and sub-

elements 264 can also be made from a suitable gauge of copper.

In a present embodiment, each trace 278 and the inner patches 270 that it interconnects are stamped or otherwise cut from a single piece of aluminum, thereby offering a simplified manufacturing process. The portion of trace 278 running parallel to cap portion 286 and the portion of each trace 278 running parallel to its respective element 258, and the junction thereof, are all impedance-matched to facilitate the manufacture of trace 278 from a single piece of aluminum and thereby help reduce the cost and/or complexity of antenna 200.

Referring now to Figures 4 and 6, switching means 282 interconnects each trace 278a, 278b, 278c, 278d. In a present embodiment, switching means 282 includes four PIN-diodes, where one PIN-diode is respective to each trace 278. Switching means 282 further includes a controller element that connects to wired link 202. (While not shown in the Figures, in the present embodiment wired link 202 enters through the hollow opening of tubular substrate 262 and passes through the interior of substrate 262 to terminate at switching means 282 on cap portion 286.) A controller element within switching means 282 is operable to extract power supplied by wired-link 202, as well as to receive a control signal carried within wired link 202. The controller element within switching means 282 is operable to activate the appropriate PIN diode, or diodes, and thereby activate the corresponding element or elements 258, according to the extracted control signal. Furthermore, the controller element within switching means 282 is operable to transmit signals received, over wireless link 40, by a given element or elements 258 over wired link 202 to subscriber station 36, and to deliver signals received from subscriber station 36 to a given element or elements 258 for transmission over wireless link 40.

Referring to now to Figure 7, antenna 200 is shown intermediate base station 24, and a multipath object 300. As shown in Figure 7, base station 24 is transceiving wireless link 40. (As used herein, the term transceiving means transmitting and/or receiving.) However, in contrast to Figure 1, due to multipath object 300 wireless link 40 actually exists as two wireless links, 40_{LOS} and 40_{MP} . Thus, wireless link 40_{LOS} is a line-of-site instance of wireless link 40 between base station 24 and antenna 200, while wireless link 40_{MP} is a multipath instance of wireless link 40 between base station 24 and antenna 200. Multipath object 300 can be any object that causes multipath interference signals to exist between base station 24 and antenna 200, such as trees, rocks, buildings, walls and/or can be mobile objects such as trucks or other vehicles.

Where multipath object 300 can move, it will be understood that wireless link 40_{MP} can change depending on the location of object 300. Additionally, it will be understood that Figure 7 is a simplified example of links, 40_{LOS} and 40_{MP} and that more complex, and multiple multipath links 40_{MP} can exist between base station 24 and steerable antenna 200. Further – it will be also understood that subscriber station 36 can be positioned in relation to base station 24 such that no line-of-site link 40_{LOS} instance is available to subscriber station 36, and that in such cases only one or more multipath links 40_{MP} may be available to subscriber station 36. Finally, a link 40 may be subject to Rayleigh fading or other phenomena which result in significant changes to its transmission characteristics with time. As will be explained in greater detail below, antenna 200 is operable to be oriented in a direction of having a desired transmission-quality of a service over available links 40 such as the two links 40_{LOS} and 40_{MP} shown in Figure 7.

A method for operating a steerable antenna, such as antenna 200 in a WLL system will now be discussed with reference to the flowchart shown in Figure 8. In order to assist in the explanation of the method, additional reference will be made to the foregoing Figures 1-7 and discussion of antenna 200. Beginning at step 400, subscriber station 36 is operated normally. Normal operation can include any number of states. For example, normal operation can be where subscriber station 36 is powered-on, and conducting an initialization sequence of loading operating system software and performing self-diagnostics, and preparing to attempt to establish communications with base station 24 over wireless link 40 using pilot channels or other signaling channels transmitted from base station 24 to subscriber station 36.

Another example of normal operation is where subscriber station 36 has already established communications with base station 24 over wireless link 40, subscriber station 36 may be carrying one or more voice telephone calls between voice terminal 44 and base station 24. Similarly, subscriber station 36 may be carrying one or more data services, (i.e. web-browsing, email) between data terminal 48 and base station 24.

Another example of normal operation is when subscriber station 36 has already established communications with base station 24 over wireless link 40, but is in an idle state where it is not carrying any service.

In the latter three examples of normal operation, it will be understood that antenna 200 will already be oriented in one particular direction towards base station 24. Other examples of normal operation of subscriber station 36 will occur to those of skill in the art.

The method then advances to step 410, where it is determined whether an appropriate time has been reached in which to orient (or reorient) antenna 200. This determination can be made based on any number of criteria, which would generally reflect the state of normal operation of subscriber station 36 at step 400 just prior to the advancement of the method to step 410. For example, where, at step 400, subscriber station 36 is attempting to establish initial communications with base station 24, then at a predetermined point during such initialization the determination at step 410 will typically determine that 'yes', now is an appropriate time to orient antenna 200, in order to allow subscriber station 36 to acquire a desired signal from base station 24.

In contrast, where at step 400 subscriber station 36 is engaged in a voice telephone call using voice terminal 44, it is generally believed that this would be an inappropriate time to reorient the antenna from an existing orientation, due to the risk of "dropping" the voice call. (While presently less preferred, it is to be understood that there can be situations where it may be desired to reorient antenna 200 during a voice call.)

Where, at step 400, subscriber station 36 is carrying a data service between data terminal 48 and base station 24, then at step 410 it may be desired to reorient antenna 200 if the bit-rate (or other metric of transection-quality) has fallen below a certain threshold. For example, where subscriber station 36 has been able to achieve a higher bit-rate when carrying previous data services between data terminal 48 and base station 24, yet at the time the method reaches step 410 this bit-rate has dropped to some appreciable amount below that higher bit-rate, then it can be desired to reorient antenna 200 in an attempt to increase the bit-rate. It is believed during the processing of a data service can be an appropriate time in which to reorient antenna 200, due to the fact that many data services, such as web-browsing and email transfer are latency tolerant, and accordingly the service can be safely, and briefly, interrupted in order to attempt to achieve a higher bit-rate through antenna reorientation.

Similarly, where, at step 400, subscriber station 36 is in an idle state (i.e, where communications with base station 24 have been established and yet no service is active), then subscriber station 36 can, at predetermined time intervals, attempt to reorient itself in relation to wireless link 40 in an attempt to secure a more desirable signal with base station 24, especially where subscriber station 36 is aware of a drop in uplink or downlink bit-rate, signal-to-noise ratio, or other measurement of transection-quality with respect to wireless link 40.

Other criteria for determining, at step 410, whether an appropriate time for orienting (or reorienting) antenna 200 has been reached will occur to those of skill in the art and are within the scope of the invention.

Referring again to Figure 8, where, at step 410 it is determined that it is not an appropriate time to orient (or reorient) antenna 200, then the method returns back to step 400 where normal operation of subscriber station 36 continues. However, if it is determined that an appropriate time has been reached to orient antenna 200, then the method advances to step 415.

When the method first advances to step 415, an initial sector in which antenna 200 can be directed is scanned and a measurement of transception-quality is taken. This initial sector can be randomly selected, a fixed pattern of sectors to be scanned can be employed, the sector which previously provided the best transception can be selected, or any other selection criteria can be used. When subscriber station 36 is operating, it is contemplated that the first sector 310 scanned at step 410 will be that sector 310 which is presently being used by subscriber station 36.

In order to explain this step and the subsequent steps, it is useful to explain the method in conjunction with examples shown in Figures 9-12. As indicated in Figure 9, it is assumed that the first sector that is scanned is sector 310a, which corresponds to element 258a. According to the previously-described configuration of antenna 200, sector 310a is scanned by sending a control signal along wired-link 202 to switching means 282 that switches the PIN diode corresponding to element 258a into the active state, thereby capturing any signal entering sector 310a and/or transmitting any uplink signal from subscriber station 36 into sector 310a. By the same token, the remaining elements 258b, 258c and 252d are switched into the inactive state, rendering them inactive.

Having scanned sector 310a, the transception-quality of wireless link 40 in sector 310a is measured and this measure is stored for later consideration. Any metric for transception-quality can be used. For example, signal-to-noise ratio, received power level, bit error rate, frame error rate or combinations thereof in the uplink and/or the downlink of wireless link 40 can be used. As will be apparent to those of skill in the art, base station 24 can also, or instead, report an appropriate metric to subscriber station 36 indicating how well it has received a transmission from subscriber station 36 transmitted through a sector 310. Thus the transception measure referred to above can be performed by the subscriber station 36, the base station 24 or both.

In the example shown in Figure 9, the measurement of transception-quality in sector 310a will be extremely poor, as neither wireless link 40_{LOS} or wireless link 40_{MP} is present in sector 310a. The method then advances to step 420, where it is determined whether all sectors have been scanned. At this point of the present example, not all of the sectors of antenna 200 have been scanned, and the method moves to step 425 and antenna 200 is advanced to a next sector. This advancement is represented in Figure 10, where sector 310d is now shown as being scanned. The scanning of sector 310d is accomplished in a manner similar to that for sector 310a, namely sector 310d is scanned by sending a control signal along wired-link 202 to switching means 282 that switches the PIN diode corresponding to element 258d in the active state. By the same token, the remaining PIN diodes for elements 258a, 258c and 252d are switched into the inactive state, rendering them inactive. Thus, any signal entering sector 310d is captured and/or any uplink signal from subscriber station 36 if transmitted in sector 310d.

The method then returns to step 415, at which point the transception-quality of sector 310d is measured and stored for later use. Again, in the example shown in Figure 10, the measurement of transception-quality in sector 310d is extremely poor, as neither wireless link 40_{LOS} or wireless link 40_{MP} is present in sector 310d.

The method then advances again to step 420, where it is determined whether all sectors have been scanned. At this point in the present example, two of the sectors 310b and 310c of antenna 200 remain unscanned, and so method moves to step 425 and a next sector is selected. This selection is represented in Figure 11, where sector 310c is now shown as being scanned. The scanning of sector 310c is accomplished in a similar manner to that described above for sectors 310a and 310d. The method then returns to step 415, at which point the transception-quality of sector 310c is measured and stored for later use. As shown in Figure 11, the measurement of transception-quality in sector 310c will detect the presence of wireless link 40_{MP} in sector 310c. It is to be understood that while wireless link 40_{MP} is a multipath instance of wireless link 40, this fact is unknown to subscriber station 36, which simply takes a measurement of link 40_{MP} using the appropriate metric.

The method then returns again to step 420, where it is determined whether all sectors have been scanned. As sector 310b of antenna 200 remains unscanned, the method moves to step 425 and antenna 200 is advanced to that sector, as represented in Figure 12, where sector 310b is now shown as being scanned. The scanning of sector 310b is accomplished as described

above for the other three sectors 310.

The method now returns once more to step 415, at which point the transception-quality of sector 310b is measured and stored for later use. Continuing with the example shown in Figure 12, the measurement of transception-quality in sector 310b detects the presence of wireless link 40_{LOS} in sector 310b. It is to be understood that while wireless link 40_{LOS} is a line-of-sight instance of wireless link 40, this fact is unknown to subscriber station 36, which simply takes a measurement of link 40_{MP} using the desired metric.

The method then returns again to step 420, where it is determined whether all sectors have been scanned. This time, it is determined that all sectors 310a, 310b, 310c and 310d have been scanned, and accordingly, the method advances to step 430.

At step 430, antenna 200 is oriented in a desired direction. This orientation is made using a selection criteria that considers the transception-quality measurements taken at step 415. The simplest selection criteria is to simply select the sector 310 with the best transception-quality, for example, where the transception-quality is measured in terms of signal-to-noise ratio (SNR), then the sector with the highest SNR will be chosen. According to the examples shown in Figures 9-12, it is generally expected that sector 310b, shown in Figure 12, would have the highest SNR, as sector 310b captures a line-of-sight instance of wireless link 40 (i.e. wireless link 40_{LOS}).

However, any selection criteria can be used, and such criteria are expected to be more complex where there are additional multipath objects 300, no line-of-sight link exists, and/or where there are multiple base stations 24 and additional subscriber stations 36 all attempting to carry voice and/or data services.

Those of skill in the art will now recognize that, in more complex situations, transception-quality will vary between the uplink and downlink of wireless link 40. For example, in a CDMA system, one selection criteria for the uplink can be to choose whichever sector 310 (or, in other words, orientation) allows subscriber station 36 to operate at the lowest possible level of transmission power thereby reducing interference with adjacent subscriber stations 36. This criteria can be useful, for example, where subscriber station 36 is simply uploading data to base station 24 over wireless link 40, and not utilizing the downlink of wireless link 40, however, where both the downlink and uplink of wireless link 40 are being utilized, more complex selection criteria can be used to achieve desired operating functionality

of system 20.

Having selected the desired sector 310 for antenna 200, the appropriate sector 310b is scanned by sending a control signal along wired-link 202 to switching means 282 that switches the PIN diode corresponding to element 258b in the active state thereby capturing any signal entering sector 310b and/or transmitting any uplink signal from sector 310b. By the same token, the remaining elements 258a, 258c and 252d are switched into the inactive state, rendering them inactive.

At this point, the method returns to step 400, where normal operation of subscriber station 36 resumes. The steps 400-430 are repeated as necessary to reorient antenna 200 in a direction that provides optimal and/or desired operation of subscriber station 36, or until wireless link 40 is broken, terminated by either subscriber station 36, base station 24 or some other multipath object 300 that causes wireless link 40 to break.

While the embodiments discussed herein are directed to specific implementations of the invention, it will be understood that combinations, sub-sets and variations of the embodiments are within the scope of the invention. For example, it is contemplated that the embodiment of Figures 4-6 can be varied so that one or more elements 258 can be activated simultaneously. This can be advantageous where wireless link 40 is incident with antenna 400 at a point in between two elements 258, in which case it can be desired to activate both adjacent elements 258 to capture wireless link 40. This situation is illustrated in Figure 13, where a sector 310ab is shown as scanned by activating element 258a and element 258b.

Additionally, while the embodiments shown in Figures 4 -6 are directed to radio communications in the PCS band, it is to be understood that the embodiments discussed herein can be modified for use in other bandwidths, and such modifications are within the scope of the invention.

Additionally, while antenna 200 in the embodiments discussed herein each elements 258 is switched with a PIN diode, such switching may be accomplished in other ways, such as through the use of GaAs FETs.

While the embodiments discussed above relate to a present embodiment of a steerable antenna for use with a wireless local loop subscriber station 36, it is to be understood that other types of steerable antennas can be used in conjunction with wireless local loop subscriber station 36, and that such other types are within the scope of the invention.

It is also contemplated that the present invention can include multiple steerable antennas attached to subscriber station 36. For example, one steerable antenna can be used for transmitting on the uplink, whereas the other antenna can be used for receiving over the downlink, and whereby each antenna can be oriented in different directions according to desired transmission-quality for the uplink, and reception-quality for the downlink. Alternatively, utilizing a variation of the embodiments shown in Figures 4-6, one element 258 could be activated for the uplink, while the other activated for the downlink, in the event that different directions could prove to be optimum for each link. For example, this could occur in systems with multiple base stations, where one element 258 is oriented towards one base station 24, while another element is oriented towards another base station 24. In this case, transception could be accomplished with the use of both base stations 24.

Furthermore, it is to be understood that where subscriber station 36 is within range of two or more base stations, then the present invention can be used to allow a subscriber station 36 to steer its antenna towards the most desirable signal available from one of those base stations. The foregoing aspect of the invention can be utilized with soft-handoff or other types of handoff techniques.

It is also contemplated that the present invention can be modified to provide a wireless local loop subscriber station with one or more steerable antennas that are steerable in multiple planes: for example, steerable in both horizontal planes and vertical planes, in order to allow the antenna to be directed in both the horizontal and vertical planes to achieve a desired transception-quality.

The configuration of each element 258 in the embodiments shown in Figure 4-6 can be described as a double-coupled patch antenna. It is to be understood, however, that each element 258 could be configured differently, depending on the desired characteristics of antenna 200. For example, in the present embodiment, each outer patch 274 serves as a parasitic element to its respective inner patch 270, thereby improving performance over entire the entire PCS band. It is to be understood, however, that the use of such a parasitic element is optional. Furthermore, the utilization of two sub-elements 264 in the vertical plane can narrow, in relation to the use of one sub-element 264, the elevation plane in which a particular element 258 operates. Accordingly, additional or fewer sub-elements 264, in either the horizontal or vertical planes can be chosen to provide a desired aperture of each element 258. For example, another embodiment

of antenna 200 can have a single sub-element 264 per element 258 to reduce the vertical size of antenna 500, albeit at a likely cost in terms of the performance of antenna 200.

Furthermore, while the embodiment shown in Figure 4-6 has four elements 258, antenna 200 can have additional or fewer elements 258, as desired. It is also to be understood that other types of elements 258 can be used. For example, the embodiments discussed herein elements 258 are essentially four individual directional antennas, yet in other embodiments there could be a single active antenna element with a plurality of parasitic elements that could be switched in or out, to influence the radio signal in relation to the active element.

Furthermore, it is contemplated that the present invention could be offered as kit in addition to the wireless local loop subscriber station having an internal steerable antenna, as taught in the above-mentioned co-pending application. In this case, additional circuitry would be provided within subscriber station 36 to accommodate the attachment of the external antenna 200 shown in Figures 4-6, allowing subscriber station 36 to switch between utilization of its own, internal antenna, or an external steerable antenna 200 of the like discussed herein.

Figure 14 shows a block diagram of another embodiment of an antenna 500 in accordance with the present invention. This embodiment is intended to be used as an option with a standard subscriber station 36. In this case, if a subscriber station 36 cannot operate acceptably with an antenna inside its housing, then antenna 500 can be employed. For ease of installation and improved installation flexibility, antenna 500 is connected to subscriber station 36 by a user installable wired-link 202 such as RG6 coaxial cable. In order to accommodate a range of possible installation configurations, wired-link 202 can vary in length and in a present embodiment, wired-link 202 can be up to forty-five meters in length. Unfortunately, cables such as RG6 which are reasonably priced and/or are easy for a user to self install, suffer from significant line losses (represented in Figure 14 at 504). For example, for RG6 cable at the PCS band frequencies of from about 1.8 GHz to about 2.0 GHz, a signal traversing a forty-five meter length of RG6 cable can experience a 15db loss. Antenna 500 is intended to compensate for the loss of signal in wired-link 202.

Specifically, antenna 500 includes a switching means 282, as described above, and a controller element 508. As with the controller element described in the embodiments above, controller element 508 is operable to extract from and/or insert control signals and radio signals on wired-link 202 and to extract power 512 supplied to antenna 500 from wired-link 202. Power

512 is regulated and set to appropriate levels required by the various components of antenna 500, such as the low noise amplifier (LNA) 516 and the power amplifier 520.

A radio signal path extends bi-directionally from wired-link 202 through controller element 508, a step-wise attenuator 524, a power level detector 528 and a first duplexer 532. First duplexer 532 duplexes downlink radio signals amplified by LNA 516 onto the radio path and provides uplink signals to power amplifier 520. A second duplexer 536 duplexes downlink signals from switch means 282 to LNA 516 and output uplink signals amplified by power amplifier 520 to switch means 282 which connects in turn to at least one of elements 258 to complete the radio path.

Controller element 508 provides a control signal 540 to step-wise attenuator 540 and a control signal 544 to switch means 282. Controller element 508 is responsive to a control signal 548 output by power level detector 528 and to control signals from subscriber station 36 over wired-link 202.

The output of LNA 516 and the gain of power amplifier 520 are selected assuming that the cable loss 504 of wired-link 202 is at the maximum permitted loss. In a present implementation of the invention, this maximum permitted loss is 15db. Controller element 508 controls step-wise attenuator 524, as described in more detail below, to ensure that the combination of the actual cable loss 504 and the attenuation of step-wise attenuator 524 totals 15db. Thus, if a better (less-lossy) cable is employed for wired-link 202 and/or if the cable run of wired-link 202 is shorter than maximum permitted length, step-wise attenuator 524 will be set to provide additional attenuation to that provided by cable loss 504 so that the amplitude of signals into subscriber station 36 do not exceed design expectations and that signals applied to power amplifier 520 also do not exceed design specifications.

The configuration and operation of antenna 500 will now be described. When a subscriber station 36 is powered on, it determines if it is connected to antenna 500, in which case antenna 500 will be selected for radio operations by subscriber station 36. If no antenna 500 is detected, then subscriber station 36 will default to using its internal antenna.

Detection of the presence of antenna 500 is performed by subscriber station 36 assuming an antenna 500 is connected and sending an interrogation signal to it over wired-link 202. If antenna 500 is connected to subscriber station 36, controller element 508 will extract the interrogation signal, which is a defined control signal that it recognizes, and will send a reply

signal, comprising for example a model number or other identifier, to subscriber station 36 over wired-link 202. If subscriber station 36 does not receive a suitable reply message within a defined maximum time period, as for example when wired-link 202 and antenna 500 are not present, it will default to using its internal antenna.

However, if the subscriber station 36 receives the required reply within the relevant time period, it will next proceed to perform a cable loss calibration operation. Specifically, a control signal is sent over wired-link 202 and is received by controller element 508 which will turn the amplifiers (e.g. – LNA 516 and power amplifier 520) in antenna 500 to an OFF state. Next, a signal is sent by subscriber station 36 to controller element 508 to set step-wise attenuator 524 to the maximum amount of attenuation. In a present embodiment of the invention, step-wise attenuator 524 can provide 0 to 15db of attenuation, in 1db steps.

Next, the subscriber station 36 sends a signal of known power over wired-link 202 to antenna 500. As will be apparent to those of skill in the art, this signal should be selected carefully, taking into consideration the RMS transmit power levels of the inphase and quadrature signals and typically, to some extent, the temperature of the radio components. Ideally, this signal is transmitted over wired-link 202 at the midpoint of the intended uplink and downlink frequency range so that it characterizes cable loss 504 at a relevant operating condition.

At antenna 500, the signal transmitted by the subscriber station 36 is received. Controller element 508 notes the control signal 548 output to it by power level detector 528 which represents the power level of the signal after attenuation by the combination of cable loss 504 and step-wise attenuator 524. This detected power level is transmitted back to subscriber station 36, along with the present setting of step-wise attenuator 524, over wired-link 202 and, if the detected power level is within the tolerances selected for the total attenuation of cable loss 504 and step-wise attenuator 524, then the process completes, as described below. If the detected power level is lower than desired, subscriber station 36 signals controller element 508 to set step-wise attenuator 524 to the next lower level of attenuation and the process repeats until the desired power level is detected at power level detector 528.

Once the desired power level is detected at power level detector 528 and reported back to subscriber station 36, subscriber station 36 can commence normal operations. A signal is sent from subscriber station 36 to controller element 508 over wired-link 202 which controller element 508 responds to by placing the amplifiers (e.g. – LNA 516 and power amplifier 520) in

antenna 500 to the ON state and then normal operation, including the steering process described above, commences.

As should be apparent to those of skill in the art, the specific design and components described above for the embodiment of Figure 14 have been selected to reduce manufacturing costs and/or complexity while providing reasonable performance levels. However, it is also contemplated that other configurations and components can be employed with the apparent range of trade-offs in cost and performance without departing from the spirit of the invention.

In some circumstances, especially at higher operating frequencies, cable loss 504 will be difficult to compensate for. In such cases, it is contemplated that instead of sending RF (radio frequency) signals over wired-link 202, IF (intermediate frequency) signals will be sent instead as attenuation of such signals by cable loss 504 are much less and can be largely ignored. Figure 15 shows another embodiment of an antenna 600 which is similar to that discussed above with respect to Figure 14. In Figure 15, components similar to those of the embodiment of Figure 14 are identified with like reference numerals.

As shown, when IF frequency signals are sent over wired-link 202, antenna 600 includes a modulator 576 (to modulate IF signals received from subscriber station 36 to the desired RF frequency) and a demodulator 580 (to demodulate RF signals received at an element 258 to an IF frequency to be sent to subscriber station 36 over wired link 202). It is presently contemplated that a local reference oscillator signal 584 will be provided to antenna 500 from subscriber station 36 over wired-link 202 and that the modulator and demodulator will be provided with their respective frequencies from a local oscillator 590 which uses the reference signal 584. Because the cable loss 504 for such IF frequency signals is very low, no attenuator is required in this embodiment as the design assumes a minimal cable loss. With antenna 600, when subscriber station 36 starts up, the response sent by antenna 600 to the interrogation signal sent by subscriber station 36 will identify that antenna 600 employs IF frequencies over wired-link 202 and thus subscriber station 36 will not perform the signal power level evaluation and attenuator setting steps that it would perform with antenna 500.

While the discussion herein is primarily directed to fixed subscriber stations in wireless local loop systems, it will be understood that the present invention can also be applied to nomadic or mobile subscriber stations in more traditional wireless telephony and/or internet systems, by offering a means to attach such nomadic or mobile subscriber stations into an

steerable external antenna, such as that taught in the exemplary embodiments hereabove.

The present invention provides a novel antenna for a wireless local loop system. The present invention provides a steerable antenna that adds spatial diversity to a radio link between a base station and a subscriber station in a wireless local loop. Preferably, the antenna is external to the premises of the user of the subscriber station, but the steerable nature of the antenna can obviate or mitigate the requirement for professional installation, as required with prior art external antennas found in existing wireless local loop systems. Furthermore, the present invention obviates the need for professional remounting of the antenna when new base stations are added to the wireless local loop system, or where new structures arise that create unacceptable multipath interference. Additionally, since the direction of the antenna can be dynamically changed, the present invention allows for redirecting of the antenna according to changing system requirements. For example, where a first direction of the antenna affords superior bit rate transmission than a second direction that affords superior bit rate reception than the first direction, then the antenna can be changed between these two directions according to whether the subscriber stations is predominantly engaged in uplink transmission or downlink reception. Furthermore, where the use of an omnidirectional antenna can be placed in a location subject to destructive interference from multipath signals, the present invention allows the antenna to be reoriented so as to minimize the effects of the destructive interference. Furthermore, the use of two steerable antennas, one for transmission and one for reception, as taught in certain embodiments of the invention, can allow for each antenna to be oriented in different directions in order to achieve desired transmission-qualities and reception-qualities, respectively.

Finally, the present invention provides a system and method whereby an antenna with good performance may be installed, without requiring professional installers, and will self configure itself with the subscriber station 36. Requirements for expensive cables and/or fixed lengths of cable are avoided by automatically compensating for cable loss.

The above-described embodiments of the invention are intended to be examples of the present invention and alterations and modifications may be effected thereto, by those of skill in the art, without departing from the scope of the invention which is defined solely by the claims appended hereto.

We claim:

1. A wireless local loop system for carrying at least one subscriber service between a network and a subscriber terminal via a wireless link, said system comprising:
 - at least one base station interconnecting said network and said wireless link, said base station operable to transceive said service over said link; and
 - a subscriber station interconnecting said subscriber terminal and said wireless link, said subscriber station being connected by a wired-link to a steerable antenna that is mounted externally to said subscriber station and is operable to be oriented in a direction having a desired transception-quality of said service over said link.
2. The wireless local loop system of claim 1 wherein said subscriber service includes a voice service, said subscriber terminal is a voice terminal and said network includes the public switched telephone network.
3. The wireless local loop system of claim 1 wherein said subscriber service includes a data service, said subscriber terminal is a data terminal and said network includes the internet.
4. The wireless local loop system of claim 1 wherein said wireless link employs CDMA as a multiple access technique.
5. The wireless local loop system of claim 1 wherein said steerable antenna is electrically steerable.
6. The wireless local loop system of claim 5 wherein said steerable antenna includes a plurality of directional antennas each defining a different sector of coverage for said antenna, each of said directional antennas being switchable in relation to each other such that said antenna transceives said radio link in said direction.
7. The wireless local loop system of claim 6 wherein said steerable antenna includes four of said directional antennas each at an angle of ninety degrees to the other.

8. The wireless local loop system of claim 7 wherein each of said directional antennas has a coupled patch configuration.
9. The wireless local system of claim 1 wherein said transception-quality is measured using at least one of the metrics of signal-to-noise ratio, bit error rate, frame error rate, bit rate, power level and frame rate of said link.
10. The wireless local loop system of claim 1 wherein said desired transception-quality is based on an orientation of said antenna requiring a lowest emitted power level from said antenna.
11. The wireless local loop system of claim 6 wherein one of said directional antennas is selectively used for an uplink portion of said link and another of said directional antennas is selectively used for a downlink portion of said link, each of said directional antennas being selected according to a desired transmission-quality of said uplink and a desired reception-quality of said downlink.
12. The wireless local loop system of claim 1 wherein said subscriber station includes at least one steerable antenna orientable in both horizontal and vertical planes.
13. The wireless local loop system of claim 6 wherein each of said sub-elements includes a substantially octagonal outer-patch and a substantially octagonal inner-patch, said outer patch serving as a parasitic element to its said respective inner patch.
14. The wireless local loop system of claim 1 wherein said wired-link also carries power to said antenna and control signals between said antenna and said subscriber station.
15. A method of orienting a steerable antenna connected to a wireless local loop subscriber station, comprising the steps of:
 - determining an appropriate time to orient said antenna;

scanning said steerable antenna in a given orientation and measuring a transception-quality of a wireless link in said given orientation;
repeating said scanning step until a desired number of orientations have been scanned;
and
orienting said antenna towards the one said orientation that has a desired transception-quality for a subscriber service transmitted over said link.

16. The method according to claim 15 wherein each said orientation is a sector of a circle.

17. The method according to claim 15 wherein said desired number of orientations is the entire number of orientations in which said steerable antenna can be oriented.

18. The method according to claim 15 wherein said appropriate time is reached if said subscriber station is initializing communication over said wireless link between said subscriber station and a base station.

19. The method according to claim 15 wherein said appropriate time is determined based on a type of service being carried over said link.

20. The method according to claim 19 wherein said appropriate time is reached if said service is a data service that is latency tolerant.

21. The method according to claim 18 wherein said appropriate time is reached if said subscriber station is in an idle state.

22. The method according to claim 15 wherein said transception-quality is measured with at least one of the metrics of signal-to-noise ratio, bit error rate, frame error rate, bit rate, power level and frame rate of said link.

23. The method according to claim 15 wherein said link employs CDMA as a multiple access technique and said desired transception-quality is based on the one of said orientations

requiring the least emitted power level from said subscriber station.

24. A subscriber station for a wireless local loop system that carries at least one subscriber service between a network and a subscriber terminal, said system including at least one base station interconnecting said network and a wireless link, said base station operable to transceive said service over said link, said subscriber station comprising:

a microprocessor-assembly interconnecting said subscriber terminal and a modem, said microprocessor-assembly for processing said subscriber service, said modem for modulating and demodulating said service;

a radio connected to said modem and for converting said service for transception over said wireless link; and

a connection means for attaching a steerable antenna to said radio, said steerable antenna operable to be oriented in a direction that achieves a desired transception-quality of said service over said link.

25. The subscriber station of claim 24 wherein said subscriber service includes a voice service, said subscriber terminal is a voice terminal and said network includes the public switched telephone network.

26. The subscriber station of claim 24 wherein said subscriber service includes a data service, said subscriber terminal is a data terminal and said network includes the internet.

27. The subscriber station of claim 24 wherein said wireless link employs CDMA as a multiple access technique.

28. The subscriber station of claim 24 wherein said steerable antenna is electrically steerable.

29. An antenna for a wireless local loop subscriber station comprising:

a connecting means for attaching said antenna to a radio of said subscriber station; and

a plurality of directional antennas each defining a different sector of coverage for said antenna, each of said directional antennas being switchable in relation to each other such that

said antenna transceives a radio link in said direction.

30. The antenna of claim 29 wherein said steerable antenna includes four of said directional antennas at an angle of ninety degrees to the other, and each of said directional antennas having a coupled patch configuration.

31. The antenna of claim 30 wherein said coupled patch configuration includes a plurality of sub-elements.

32. The antenna of claim 29 wherein said desired transception-quality is based on an orientation of said antenna requiring a lowest emitted power level from said antenna.

33. The antenna of claim 30 wherein one of said directional antennas is selectively used for an uplink portion of said link and another of said directional antennas is selectively used for a downlink portion of said link, each of said directional antennas being selected according to a desired transmission-quality of said uplink and a desired reception-quality of said downlink.

34. The antenna of claim 30 wherein said subscriber station includes at least one steerable antenna orientable in both horizontal and vertical planes.

35. The antenna of claim 30 wherein said each of said sub-elements includes a substantially octagonal outer-patch and a substantially octagonal inner-patch, said outer patch serving as a parasitic element to its said respective inner patch.

36. The antenna according to claim 29 wherein said subscriber service includes a voice service and said subscriber terminal is a voice terminal.

37. The antenna according to claim 29 wherein said subscriber service includes a data service and said subscriber terminal is a data terminal.

38. The antenna according to claim 29 wherein said wireless link employs CDMA as a

multiple access technique.

39. An antenna for a wireless local loop subscriber station comprising:

a connecting means for attaching said antenna to a radio of said subscriber station, said connecting means carrying control signals and radio link signals between said subscriber station and said antenna and carrying power for operating said antenna from said subscriber station;

a plurality of directional antennas each defining a different sector of coverage for said antenna;

switching means to select one or more of said directional antennas for transceiving a radio link signal;

a low noise amplifier to amplify radio link signals received by said one or more directional antennas;

a power amplifier to amplify radio signals from said subscriber station radio for transmission on said radio link by said one or more directional antennas;

an adjustable attenuator to attenuate radio link signals carried over said connecting means;

a signal power level detector; and

a controller element operable to:

(a) exchange control signals between said antenna and said subscriber station over said connecting means;

(b) separate said radio link signals from said control signals

(c) separate said power for said antenna;

(d) report the power level detected by said signal power level detector and the adjustment of said adjustable attenuator to said subscriber station in a control signal;

(e) respond to control signals received from said subscriber station to configure said switching means to select one or more of said directional antennas; and

(f) respond to control signals received from said subscriber station to adjust said adjustable attenuator to a desired level.

40. The antenna of claim 39 wherein the radio link signals carried over the connector means are carried at an intermediate frequency, further comprising:

a modulator to modulate radio link signals from said connector means to the desired radio frequency for transmission from said antenna; and

a demodulator to demodulate radio link signals received by said antenna to a desired intermediate frequency for transmission to the subscriber station over said connecting means.

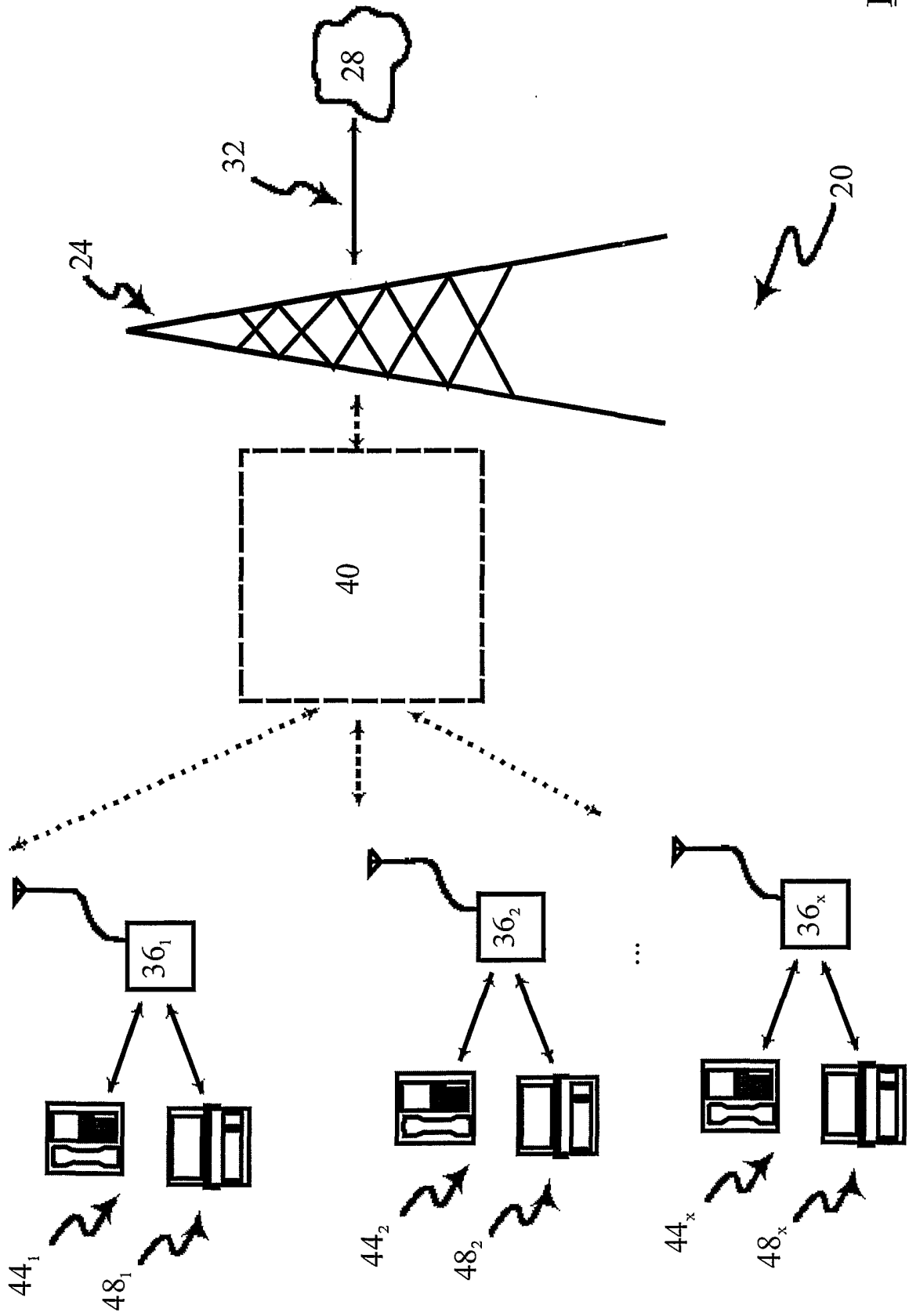


Fig. 1

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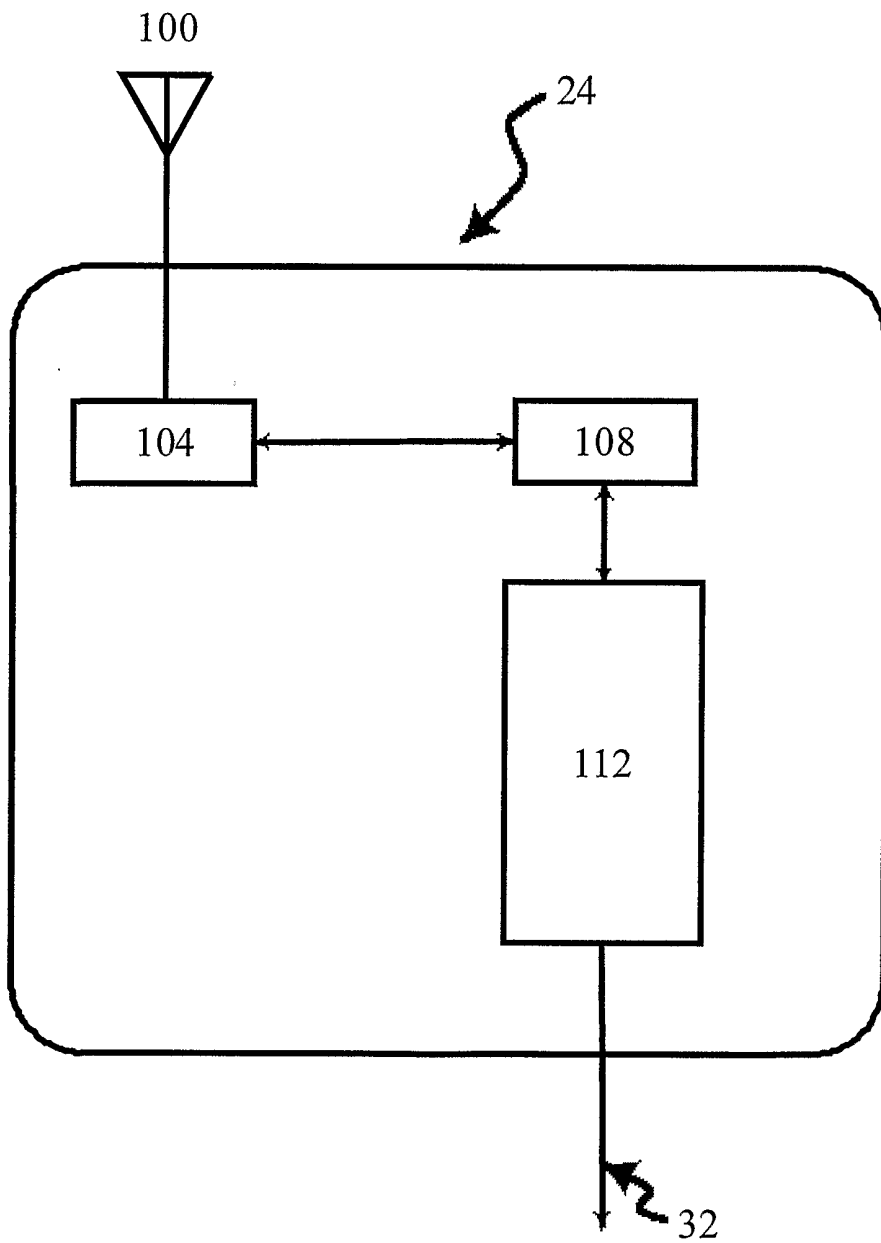


Fig. 2

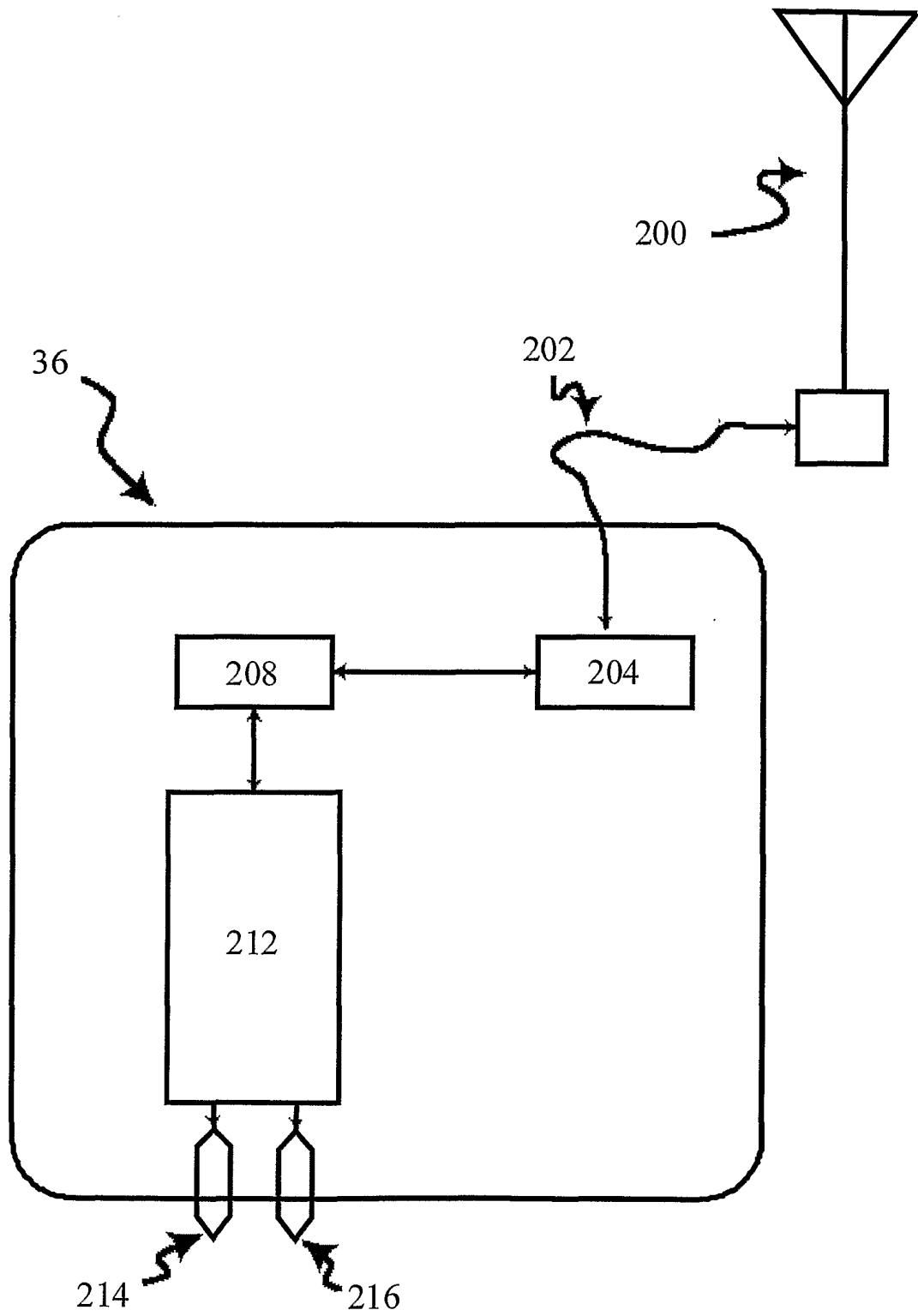


Fig.3

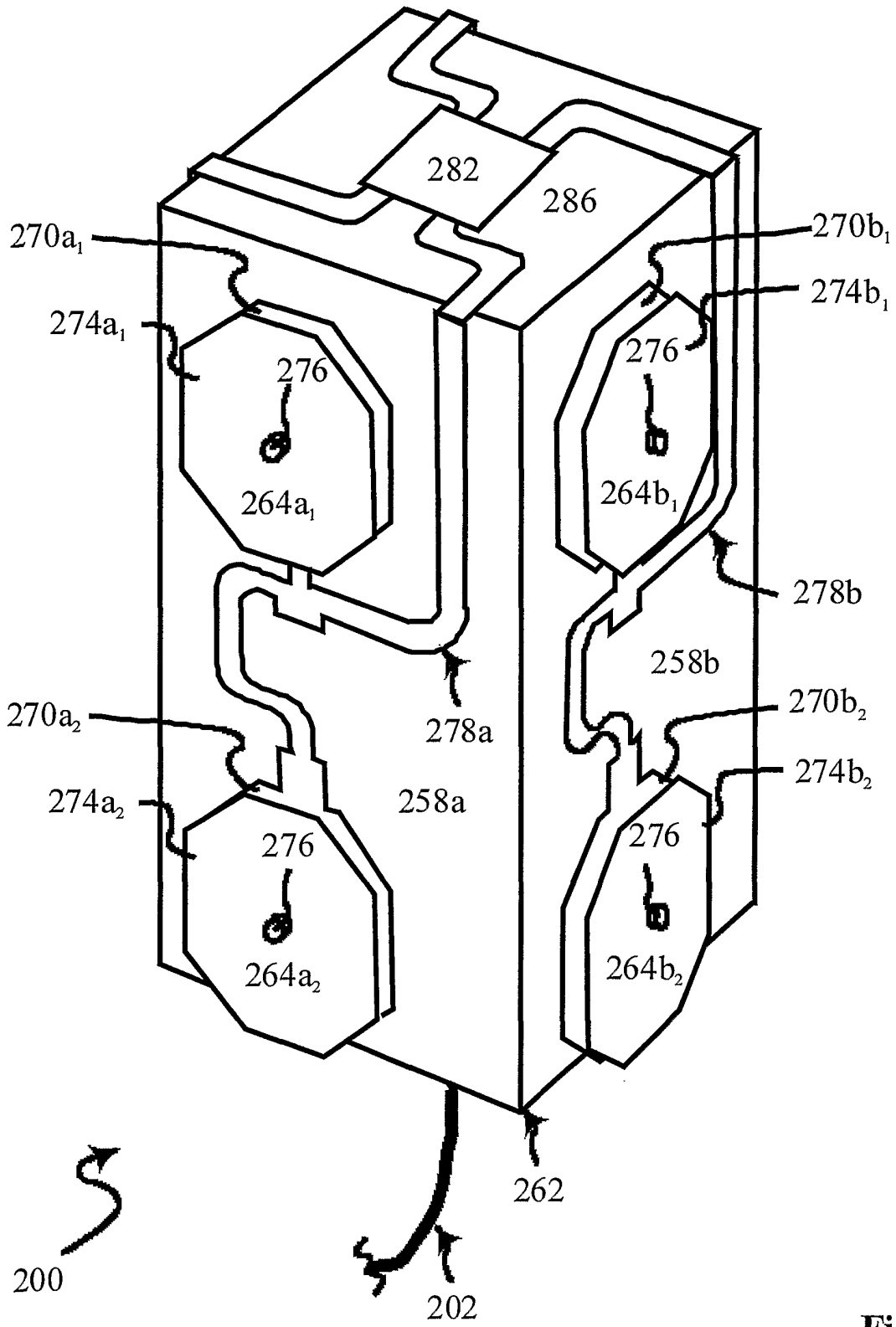


Fig. 4

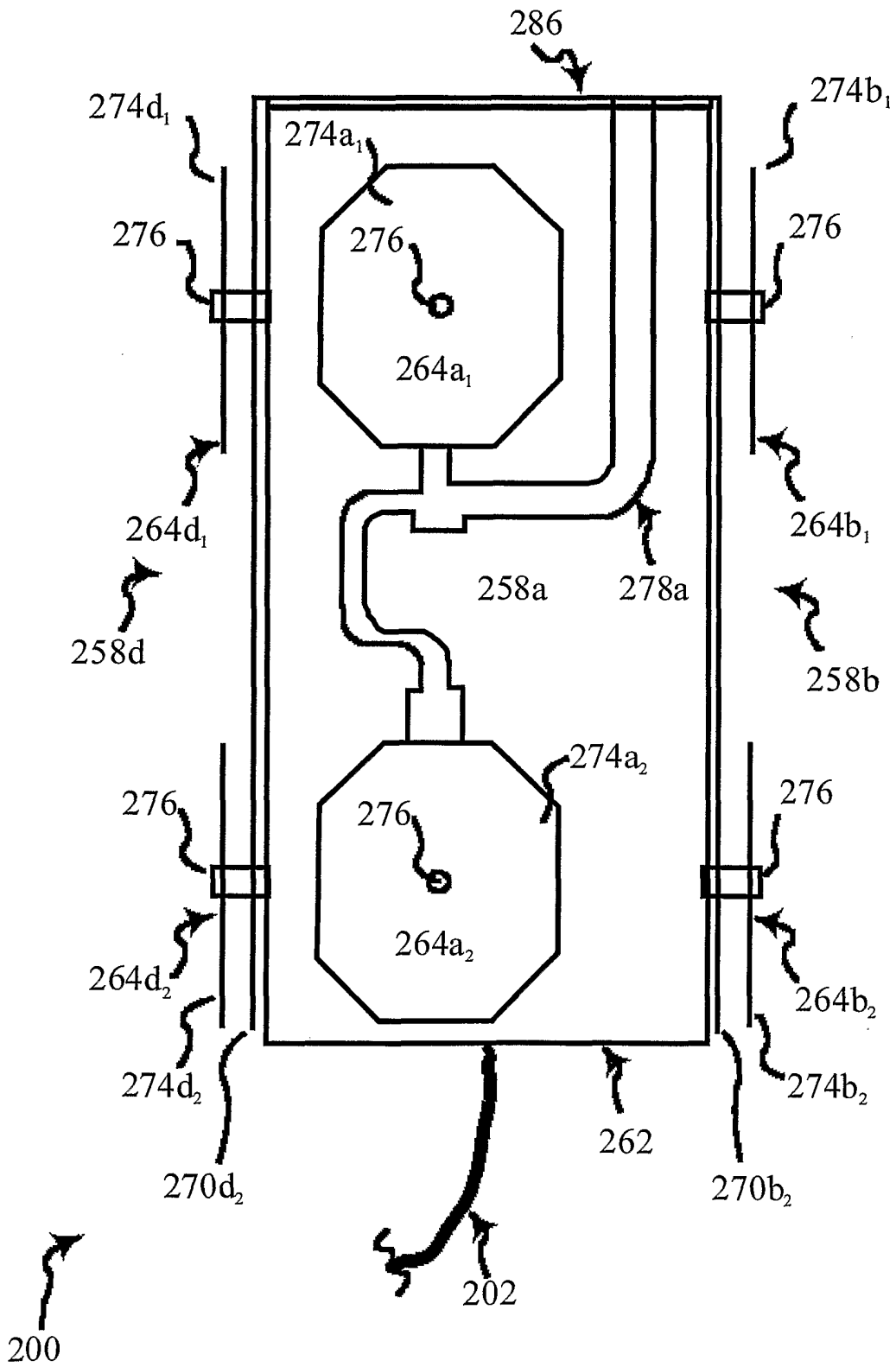


Fig. 5

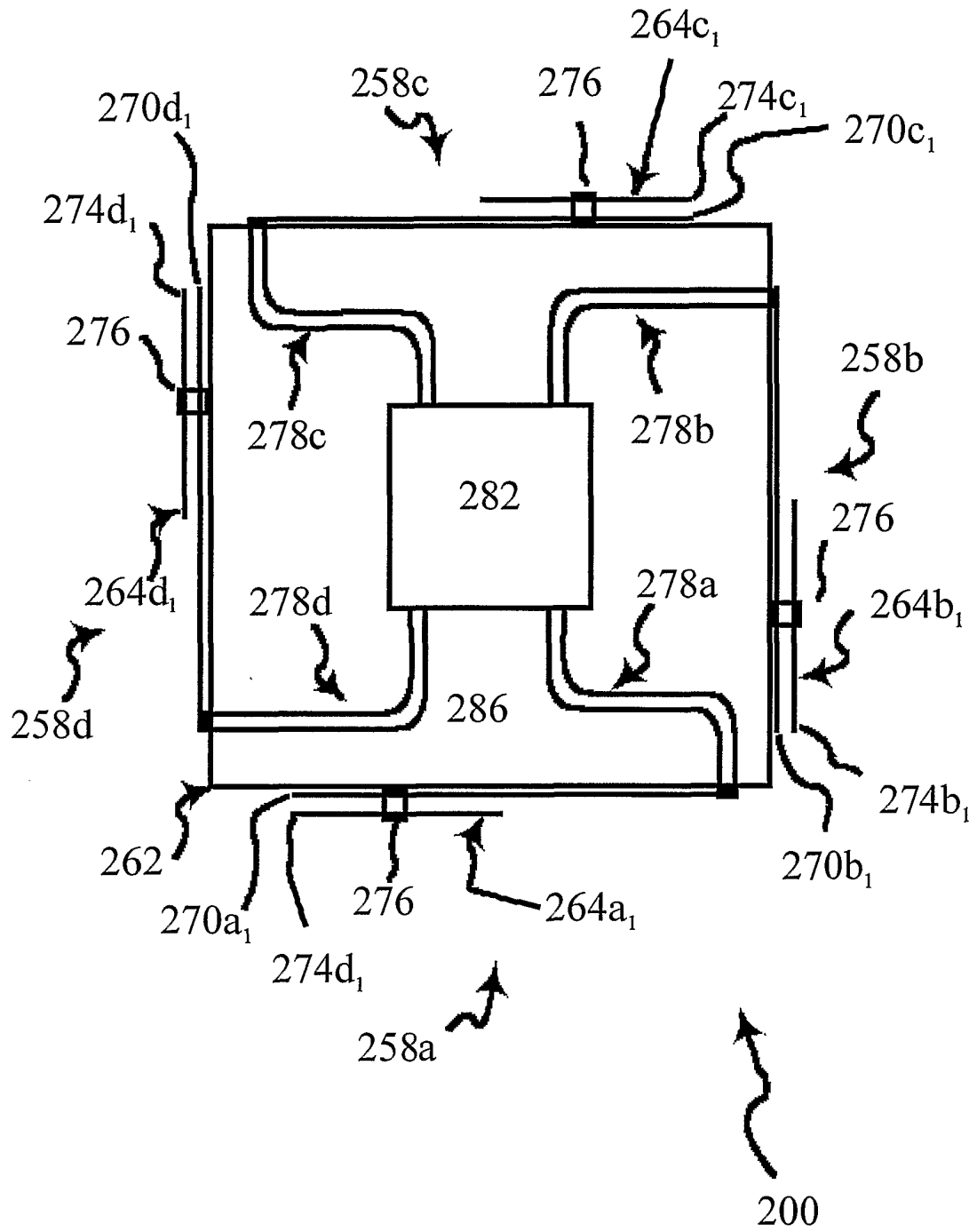


Fig. 6

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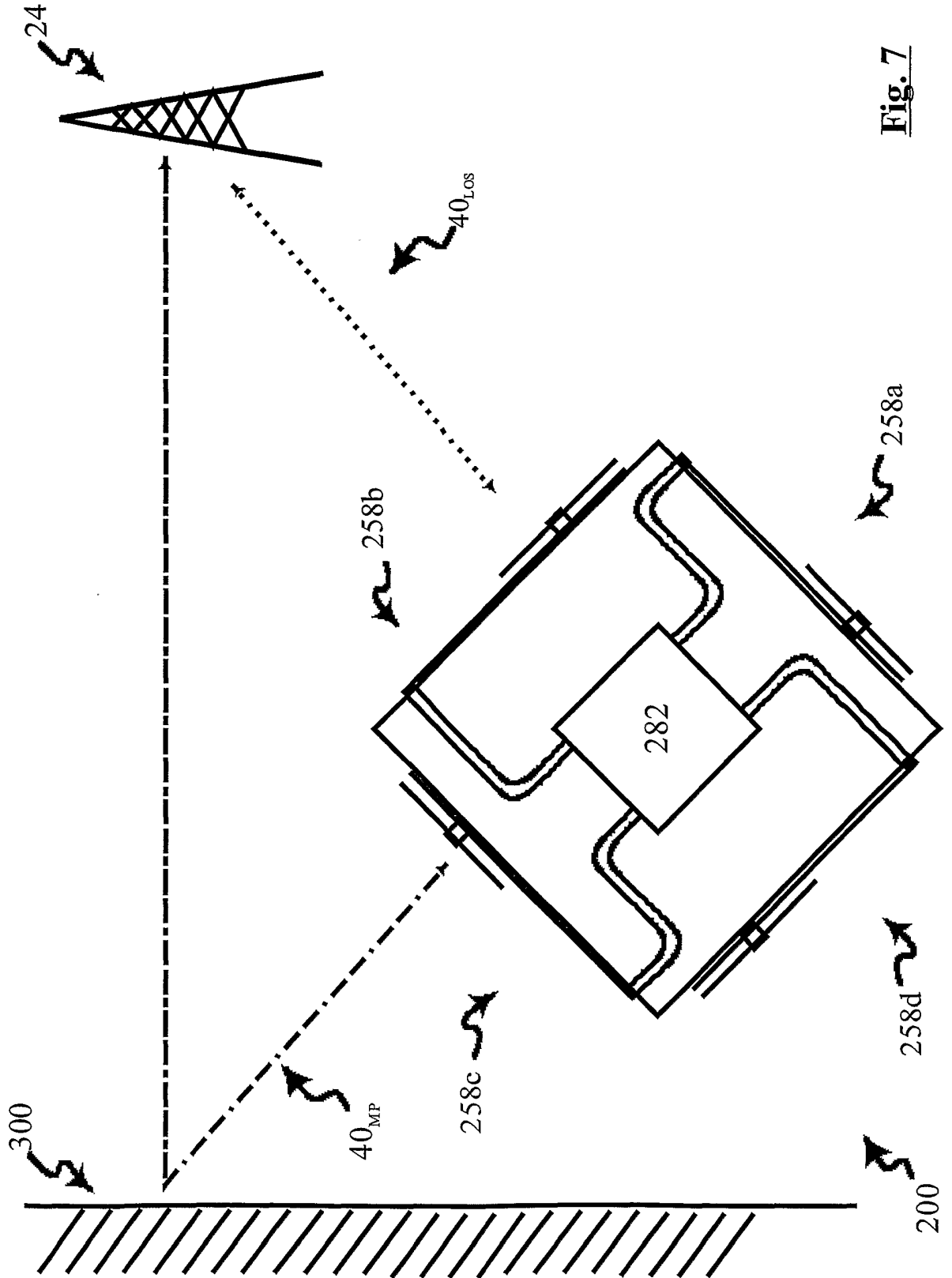


Fig. 7

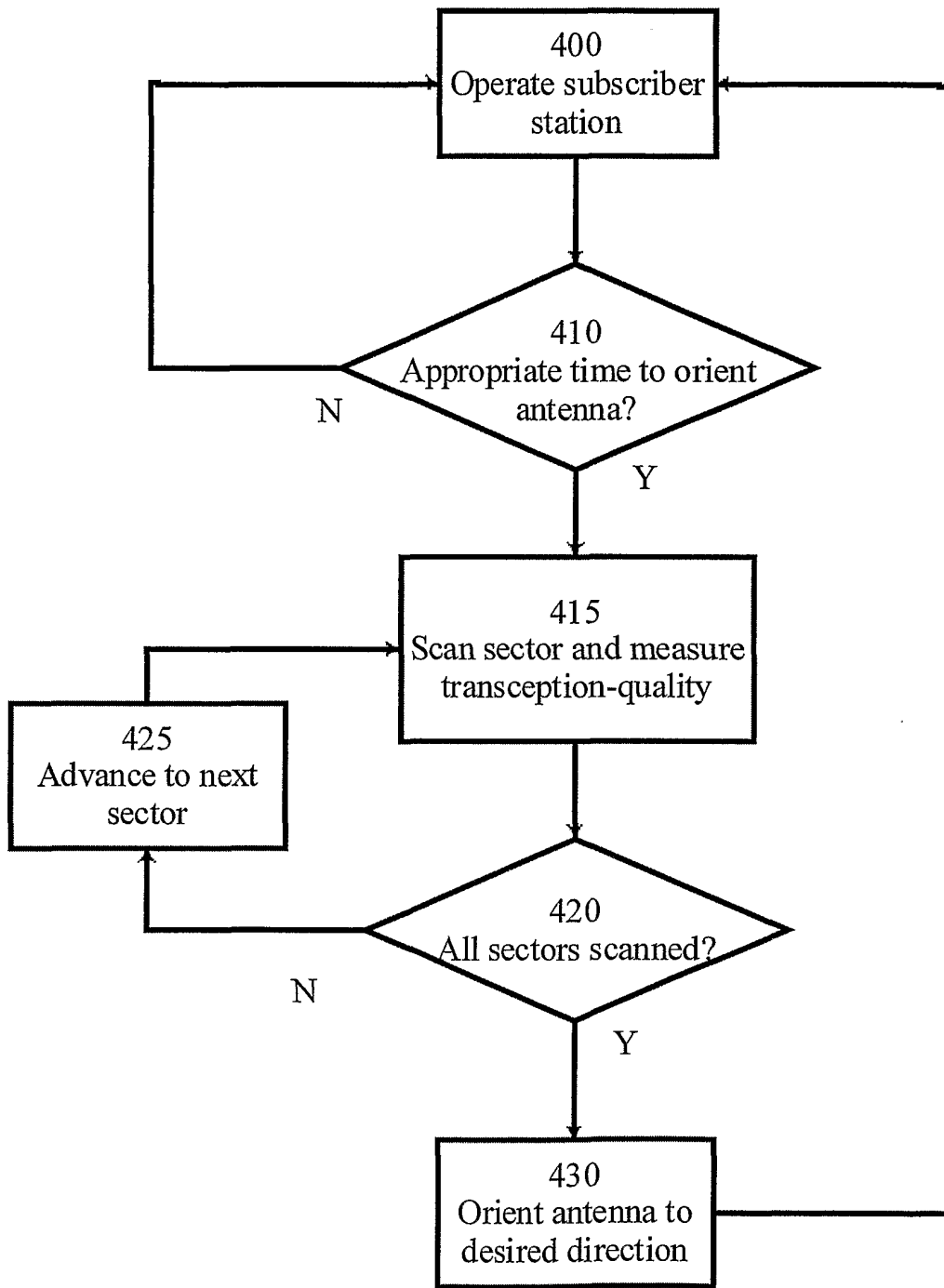


Fig. 8

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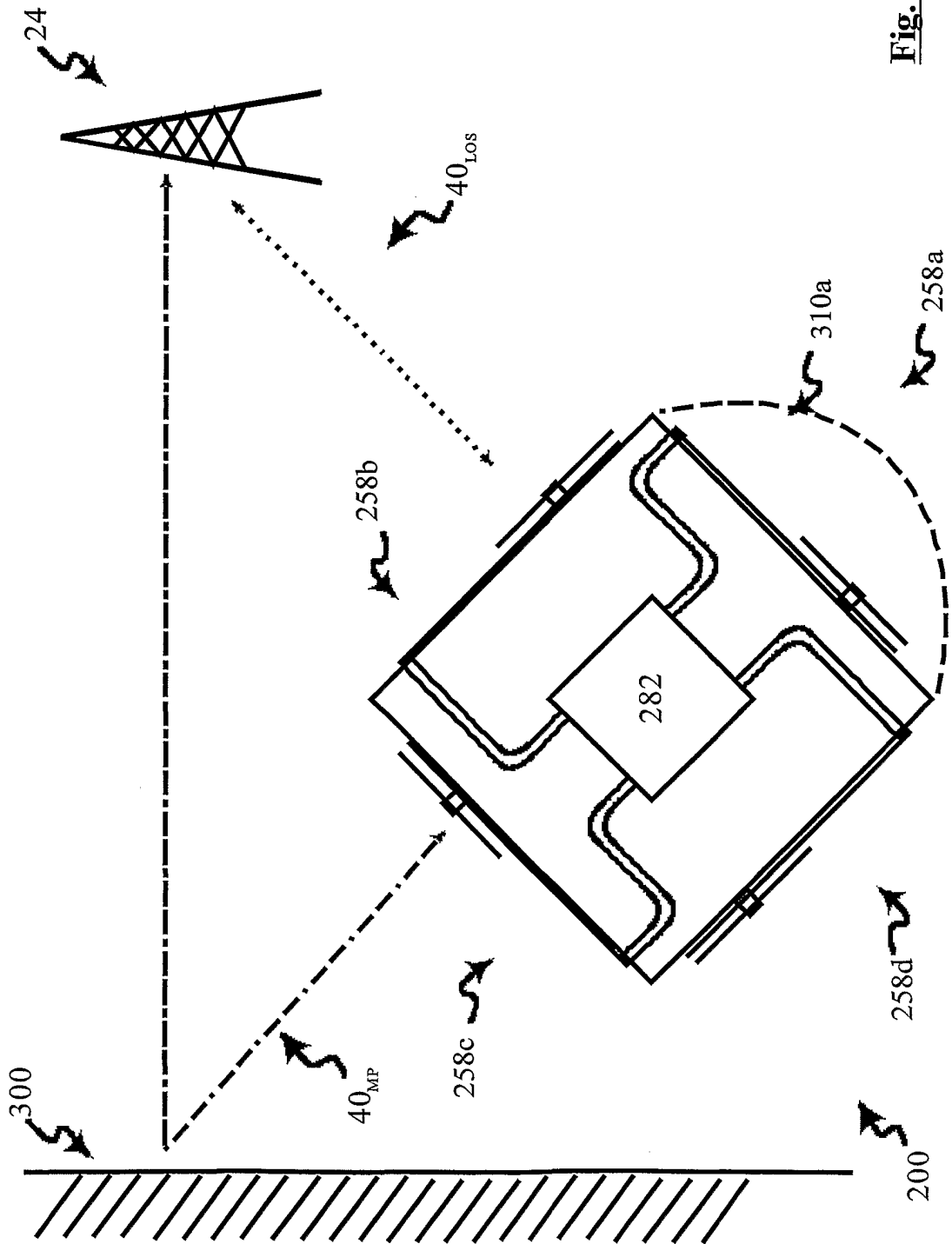


Fig. 9

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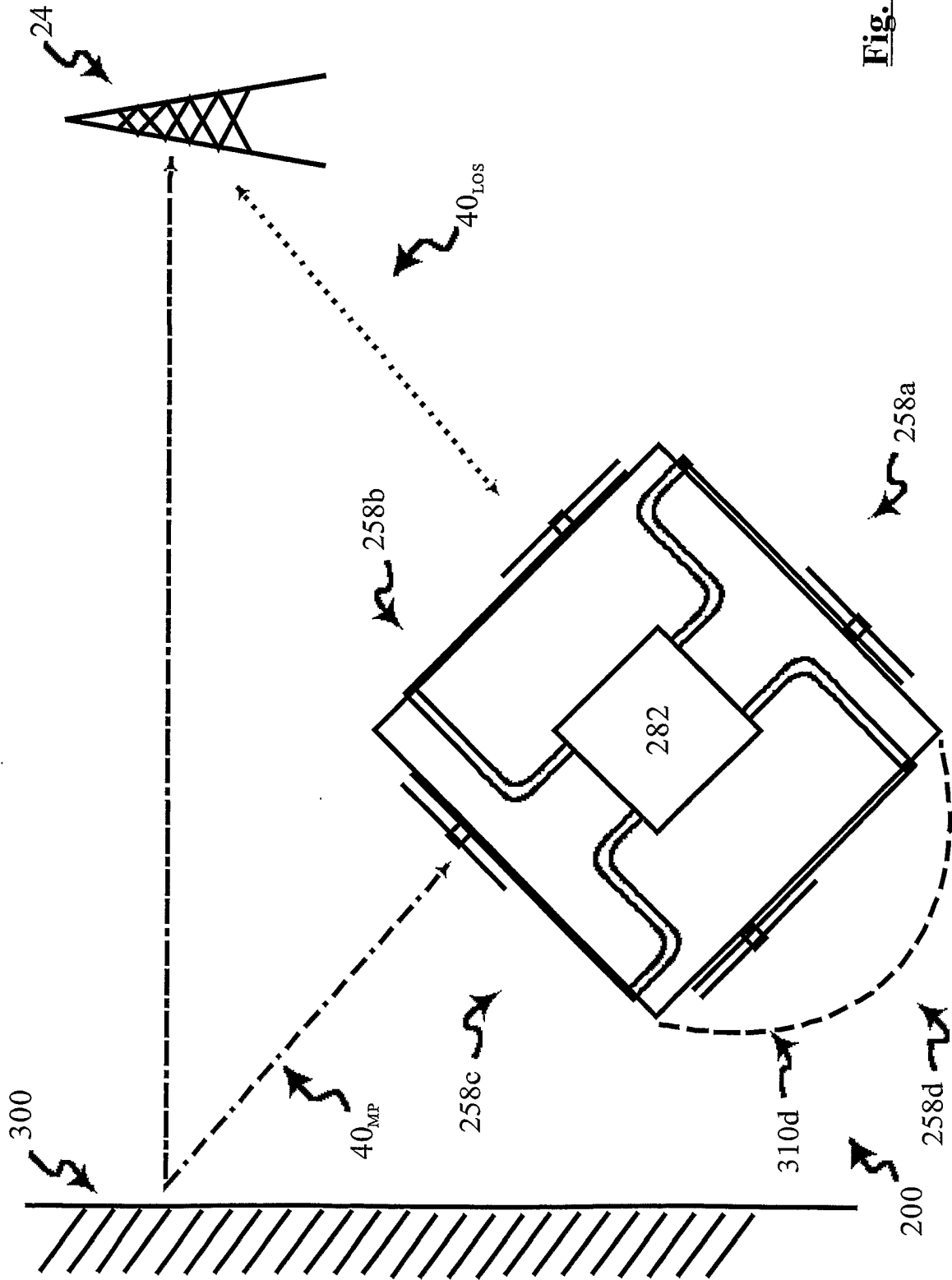


Fig. 10

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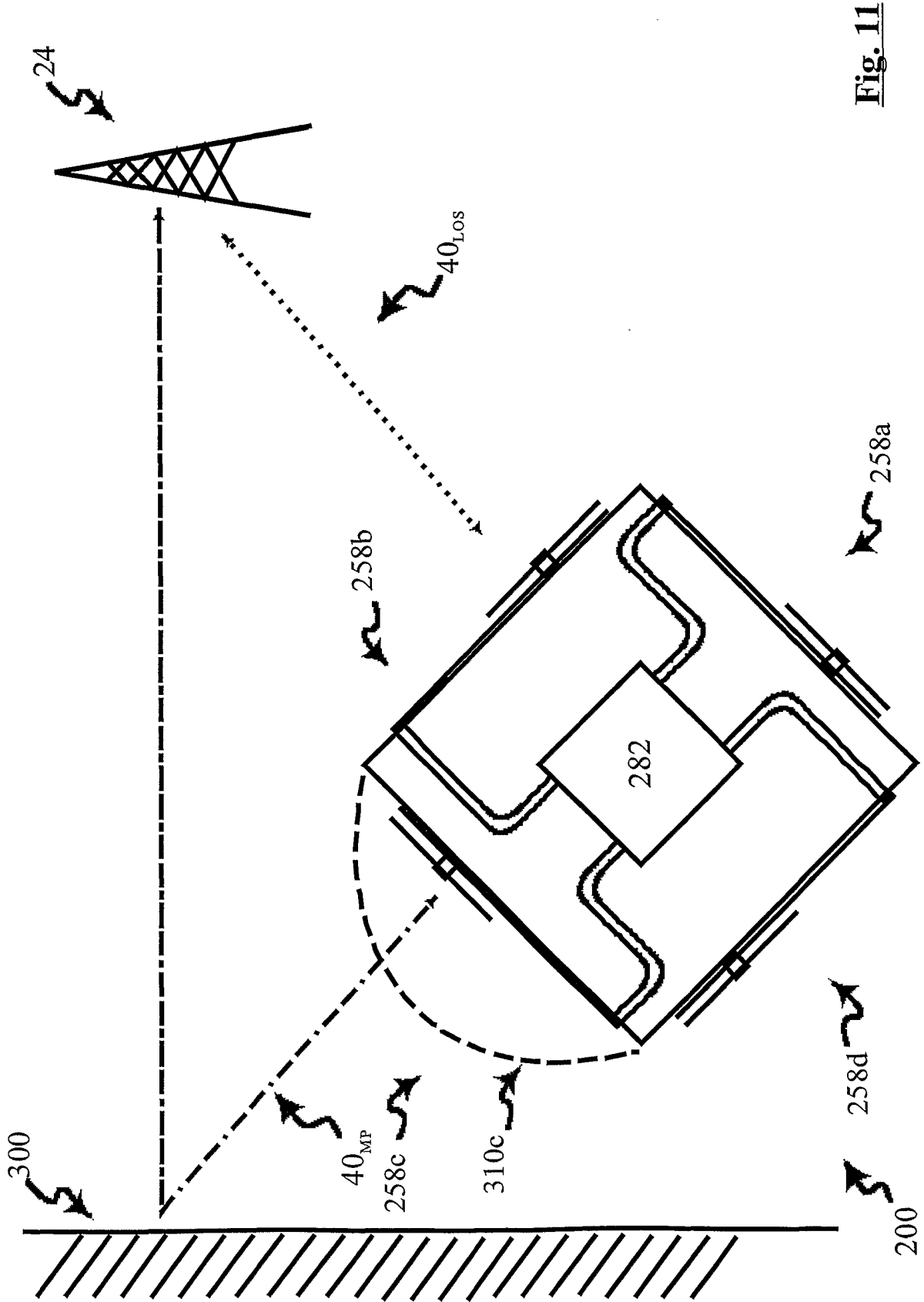


Fig. 11

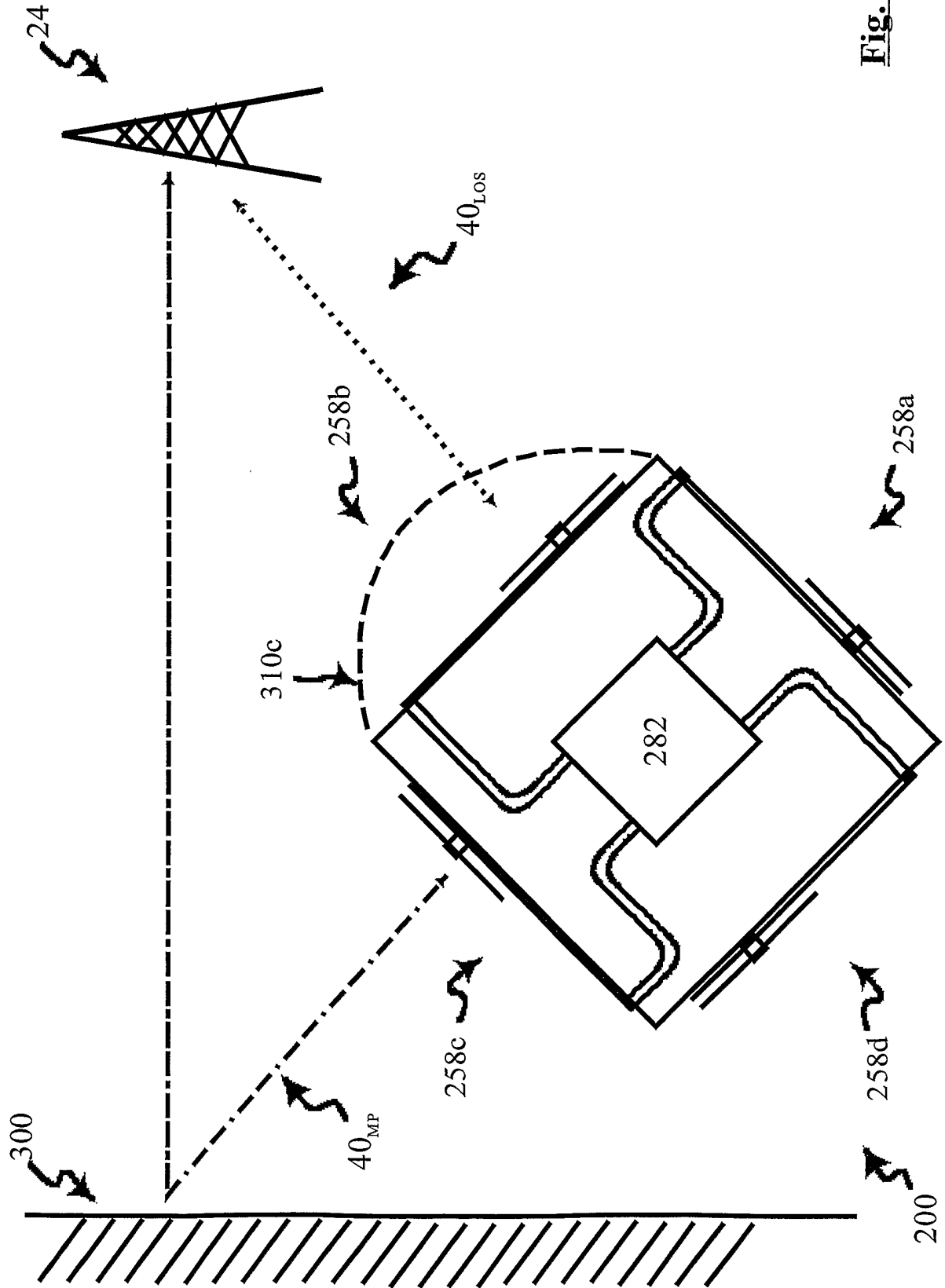


Fig. 12

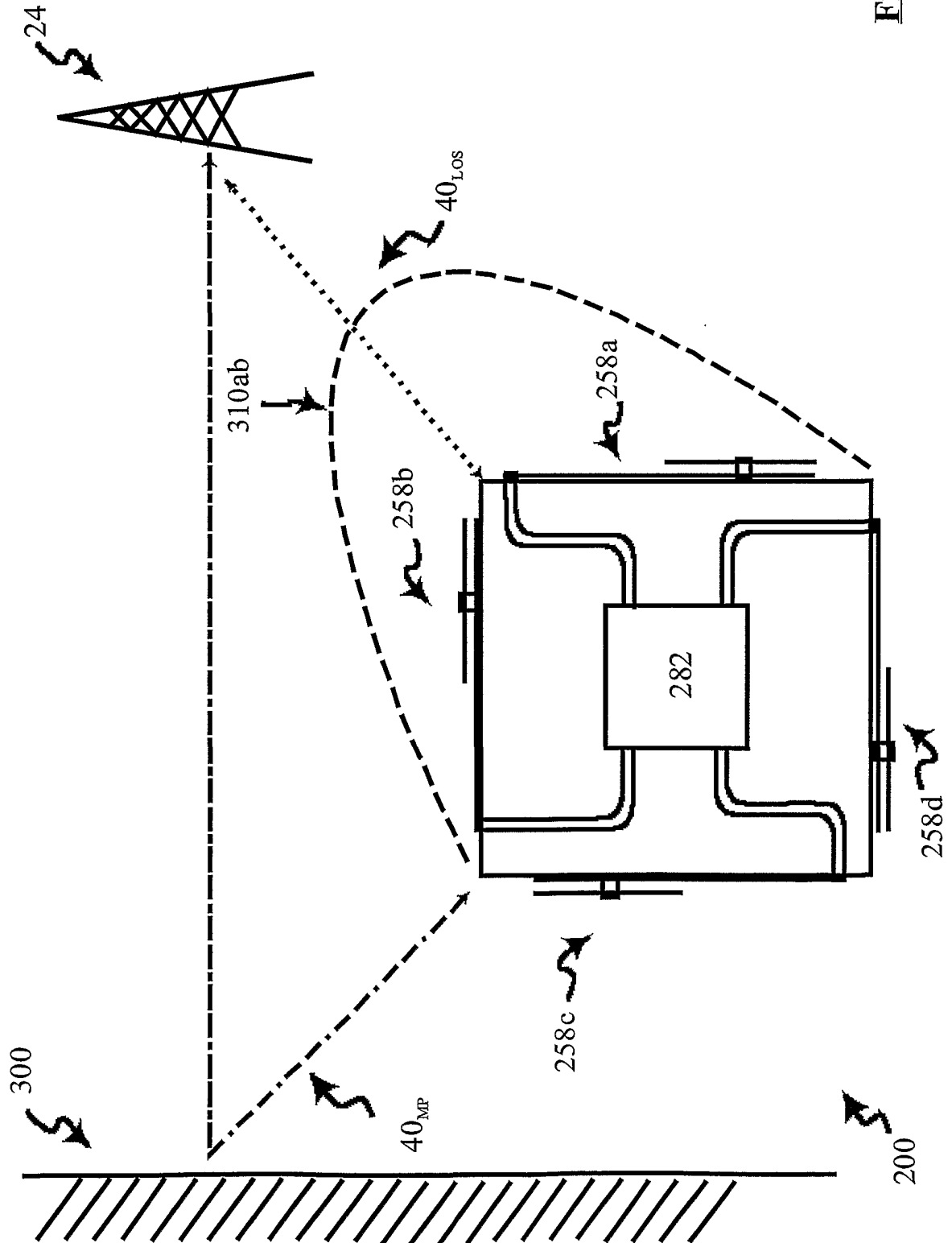


Fig. 13

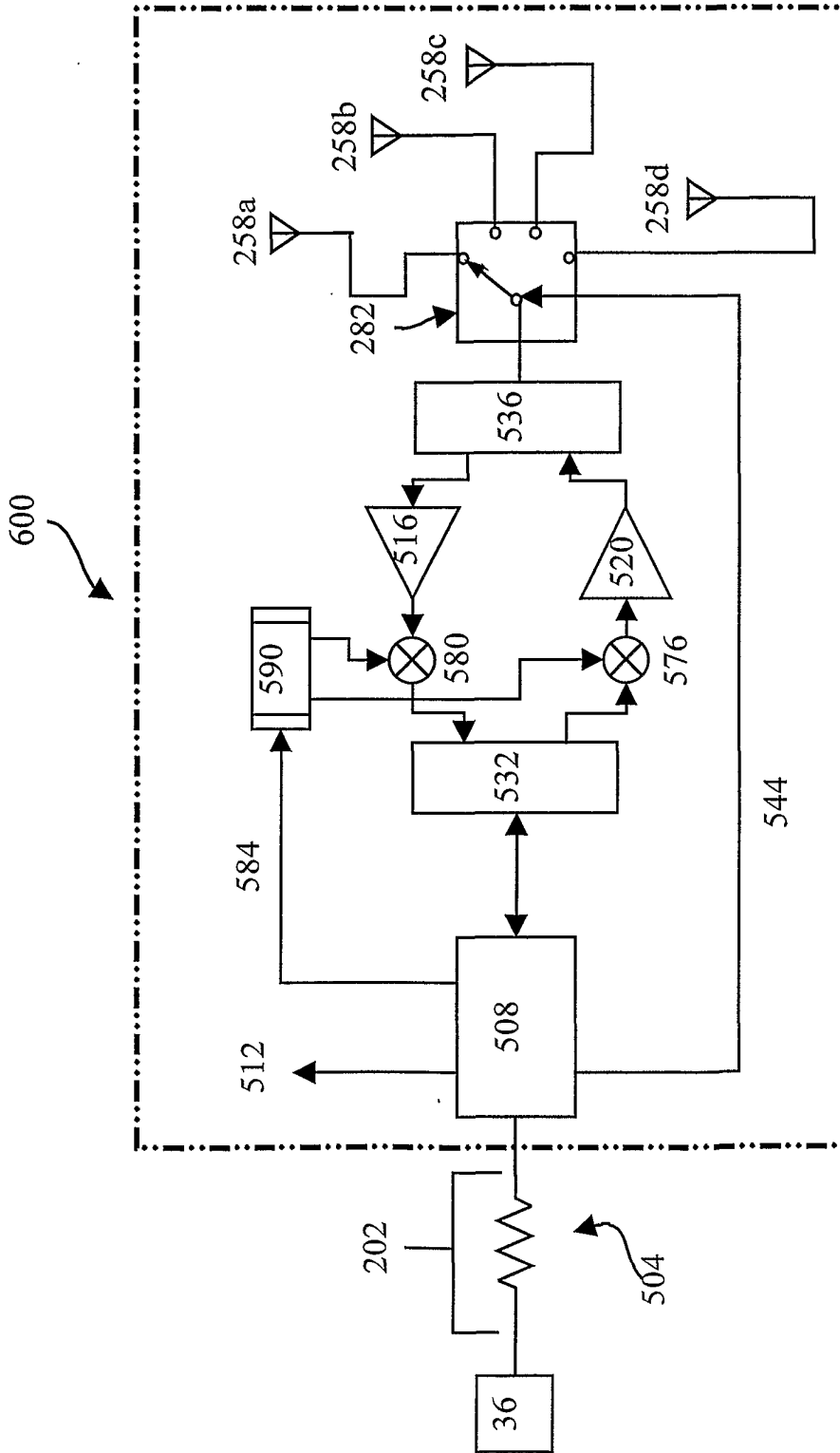
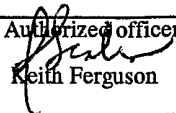


Fig. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/02759

A. CLASSIFICATION OF SUBJECT MATTER IPC(7) : H04Q 7/20, 7/32, 7/38 US CL : 455/426, 445, 424, 425, 517, 422, 403, 550, 556, 557; 343/757, 700 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) U.S. : 455/426, 445, 424, 425, 517, 422, 403, 550, 556, 557; 343/757, 700 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched none Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) east		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,150,987 A (SOLE et al.) 21 November 2000, see whole document.	1,2,5,6,8,15,16,17,24, 25,28,29,36,37
A	US 6,163,299 A (PARK) 19 December 2000, see abstract, fig. 4.	1-38
Y	US 6,121,929 A (OLSEN et al.) 19 September 2000, see whole document.	1,2,5,6,8,15,15,17,24, 25,28,29,36,37
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 22 April 2002 (22.04.2002)	Date of mailing of the international search report 30 MAY 2002	
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer  Keith Ferguson Telephone No. (703) 305-4888	