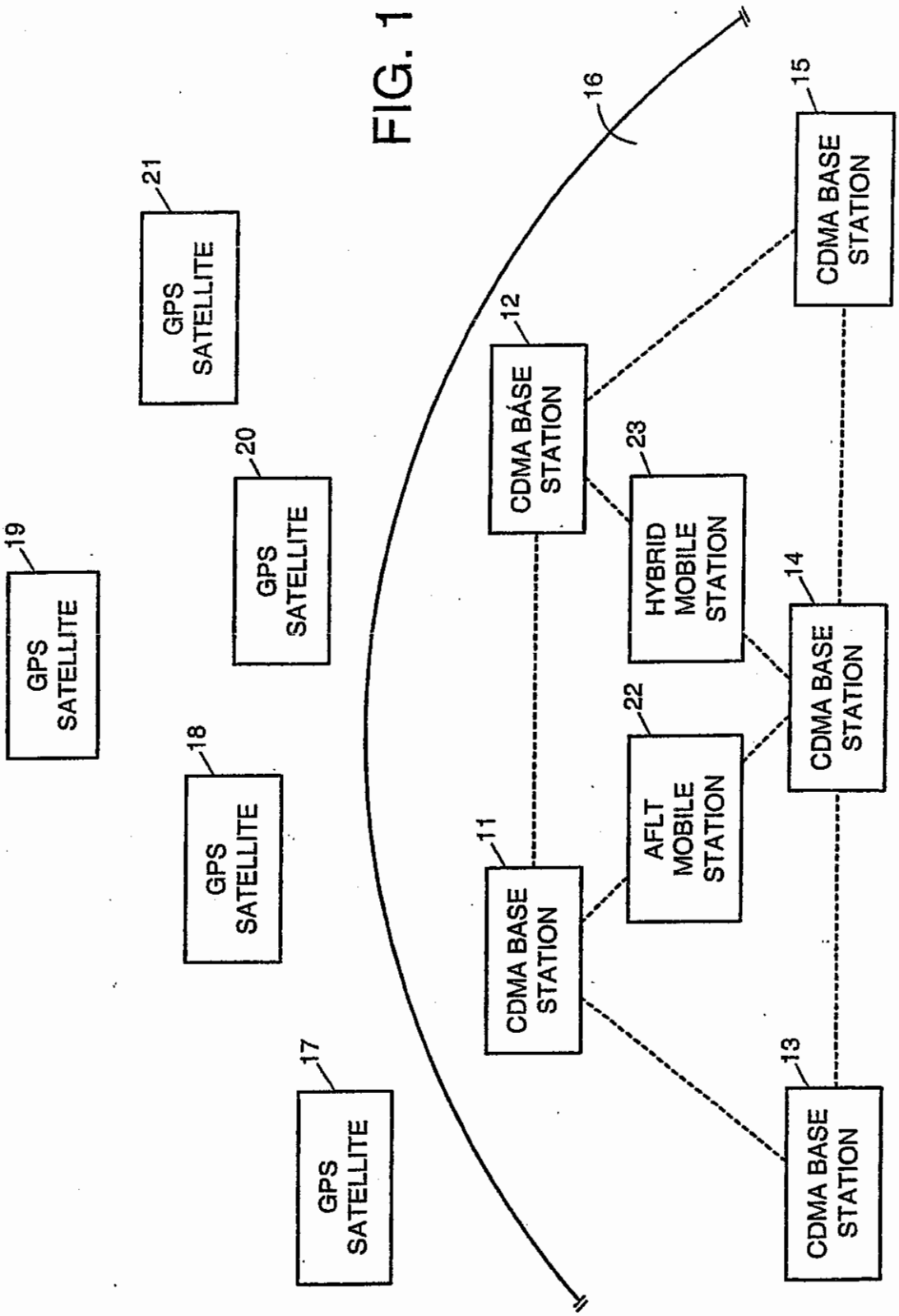
FIG. 1


GPS SATELLITE
19
GPS SATELLITE
18
GPS SATELLITE
17
GPS SATELLITE
21
GPS SATELLITE
20
16
CDMA BASE STATION
15
CDMA BÁSE STATION
12
HYBRID MOBILE STATION
23
CDMA BASE STATION
14
AFLT MOBILE STATION
22
CDMA BASE STATION
11
CDMA BASE STATION
13

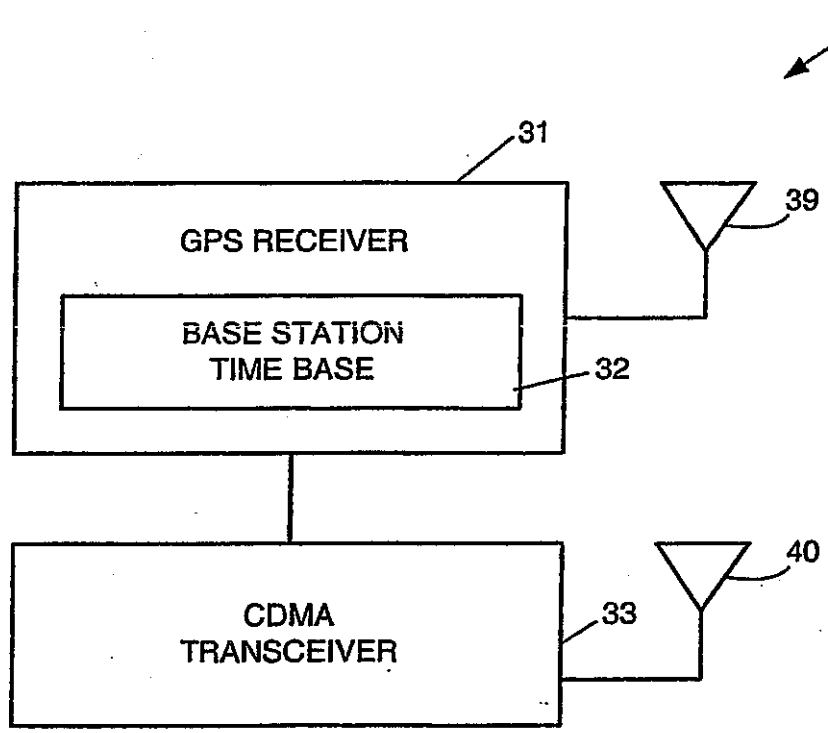

11
31
39
GPS RECEIVER
BASE STATION
TIME BASE
32
40
CDMA
TRANSCEIVER
33

FIG. 2

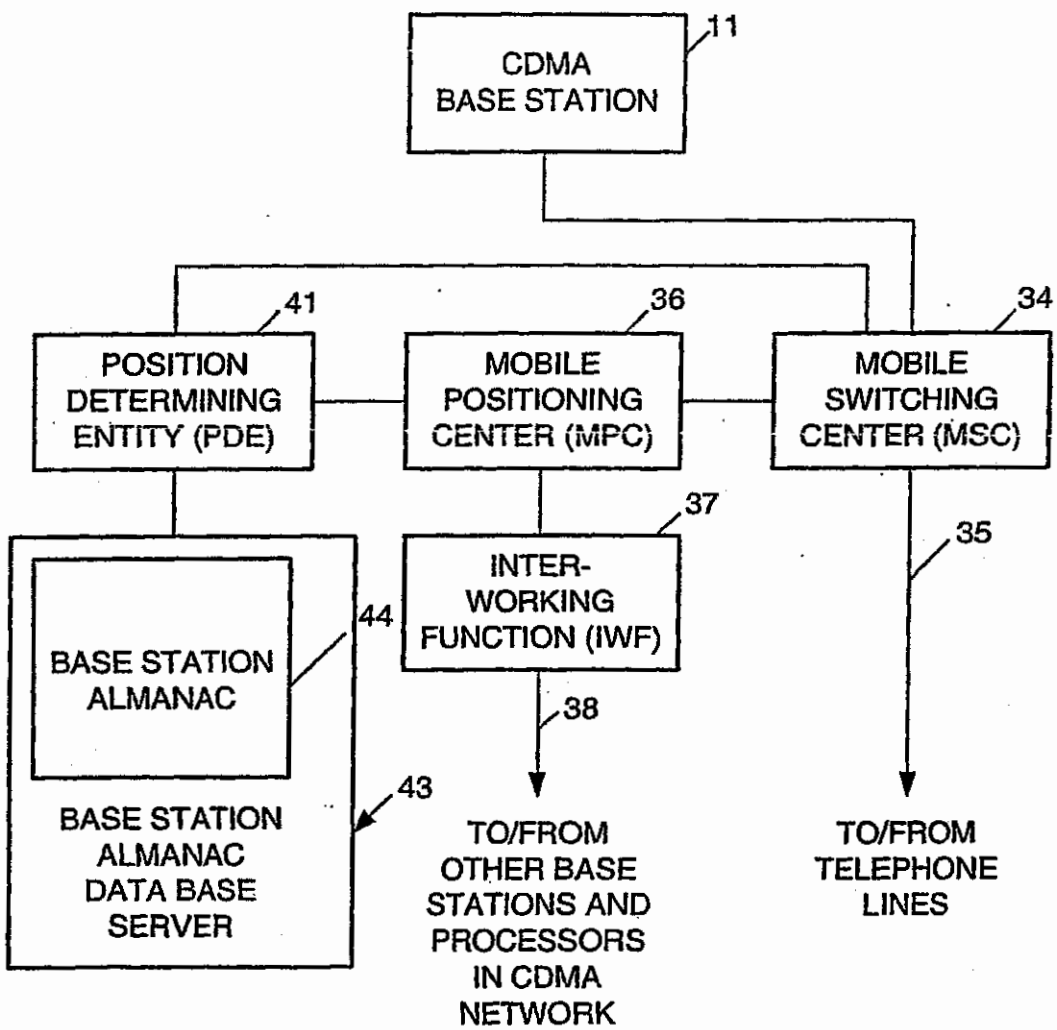

CDMA BASE STATION
11
POSITION DETERMINING ENTITY (PDE)
41
MOBILE POSITIONING CENTER (MPC)
36
MOBILE SWITCHING CENTER (MSC)
34
INTER-WORKING FUNCTION (IWF)
37
35
BASE STATION ALMANAC
44
BASE STATION ALMANAC DATA BASE SERVER
43
38
TO/FROM OTHER BASE STATIONS AND PROCESSORS IN CDMA NETWORK
TO/FROM TELEPHONE LINES

FIG. 3

FIELD NAME	DESCRIPTION
Pilot sector name	50-byte ASCII string
System ID	INT2 (16 bits)
Network ID	INT2 (16 bits)
Extended base ID	INT4 (32 bits)
Transmit PN	INT4 (32 bits)
Antenna latitude	DOUBLE (64 bits) degrees
Antenna longitude	DOUBLE (64 bits) degrees
Antenna altitude	INT4 (32 bits) meters
Antenna location accuracy	UINT2 (16 bits) centimeters
Antenna orientation	INT4 (32 bits) degrees
Antenna opening	INT4 (32 bits) degrees
Maximum antenna range	INT4 (32 bits) meters
Rtd calibration	DOUBLE (64 bits) chipx8
Rtd calibration accuracy	UINT2 (16 bits) chipx64
Fwd link calibration	DOUBLE (64 bits) chipx8
Fwd link calibration accuracy	UINT2 (16 bits) chipx64
Potential repeater	INT2 (16 bits)
PN increment	INT2 (16 bits)
Format Type	UCHAR (8 bits)
MSC Switch Number	INT2 (16 bits)

FIG. 4

FIELD NAME	DESCRIPTION
Sector Center Latitude	DOUBLE (64 bits) degrees
Sector Center Longitude	DOUBLE (64 bits) degrees
Sector Center Altitude	INT4 (32 bits) meters
Terrain Average Height	INT4 (32 bits) meters
Terrain Height Standard Dev.	INT4 (32 bits) meters

FIG. 5

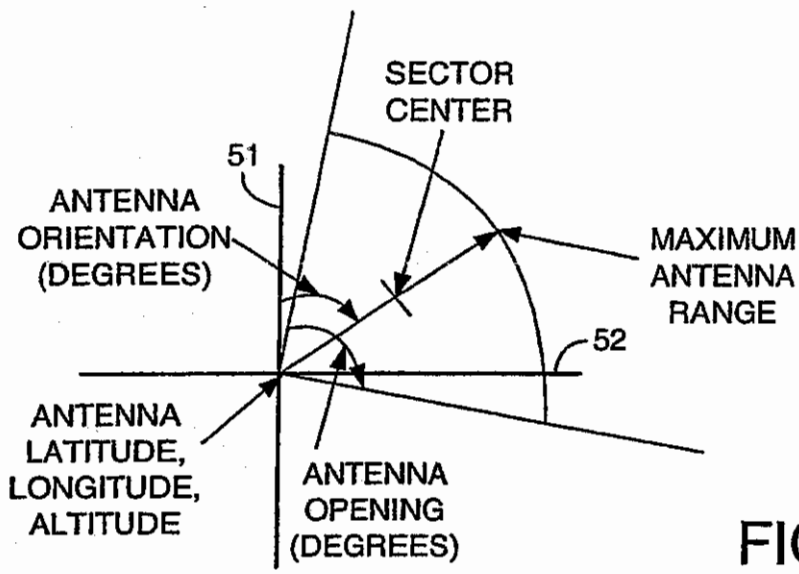

SECTOR
CENTER
51
ANTENNA
ORIENTATION
(DEGREES)
MAXIMUM
ANTENNA
RANGE
52
ANTENNA
LATITUDE,
LONGITUDE,
ALTITUDE
ANTENNA
OPENING
(DEGREES)

FIG. 6

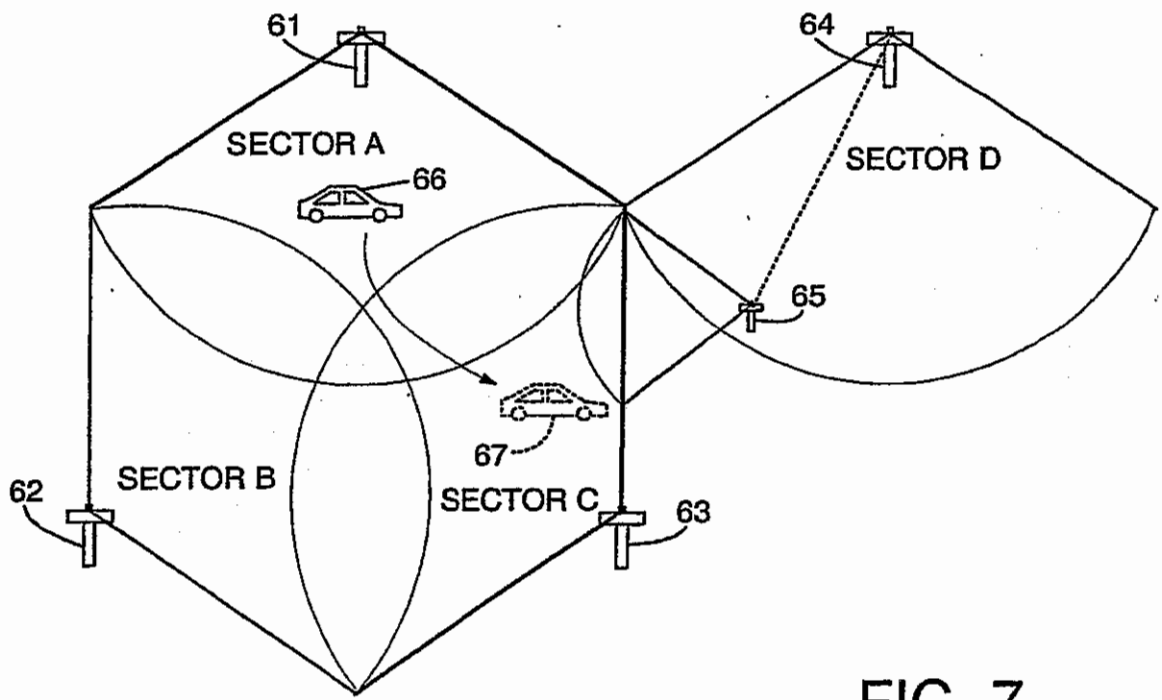

61
64
SECTOR A
66
SECTOR D
65
67
62
SECTOR B
SECTOR C
63

FIG. 7

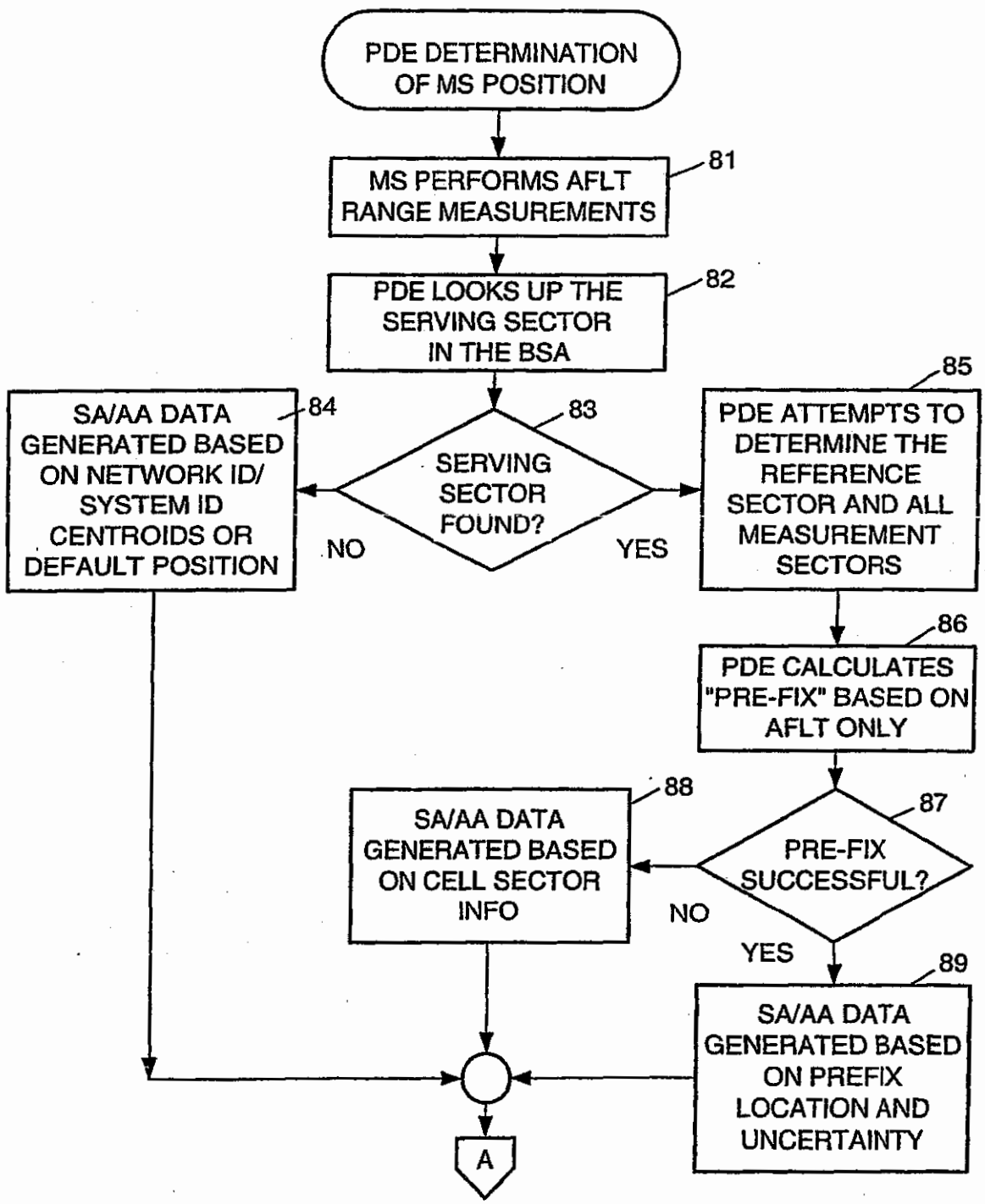

PDE DETERMINATION OF MS POSITION
MS PERFORMS AFLT RANGE MEASUREMENTS
81
PDE LOOKS UP THE SERVING SECTOR IN THE BSA
82
SERVING SECTOR FOUND?
83
NO
YES
SA/AA DATA GENERATED BASED ON NETWORK ID/ SYSTEM ID CENTROIDS OR DEFAULT POSITION
84
PDE ATTEMPTS TO DETERMINE THE REFERENCE SECTOR AND ALL MEASUREMENT SECTORS
85
PDE CALCULATES "PRE-FIX" BASED ON AFLT ONLY
86
PRE-FIX SUCCESSFUL?
87
NO
YES
SA/AA DATA GENERATED BASED ON CELL SECTOR INFO
88
SA/AA DATA GENERATED BASED ON PREFIX LOCATION AND UNCERTAINTY
89
A

FIG. 8

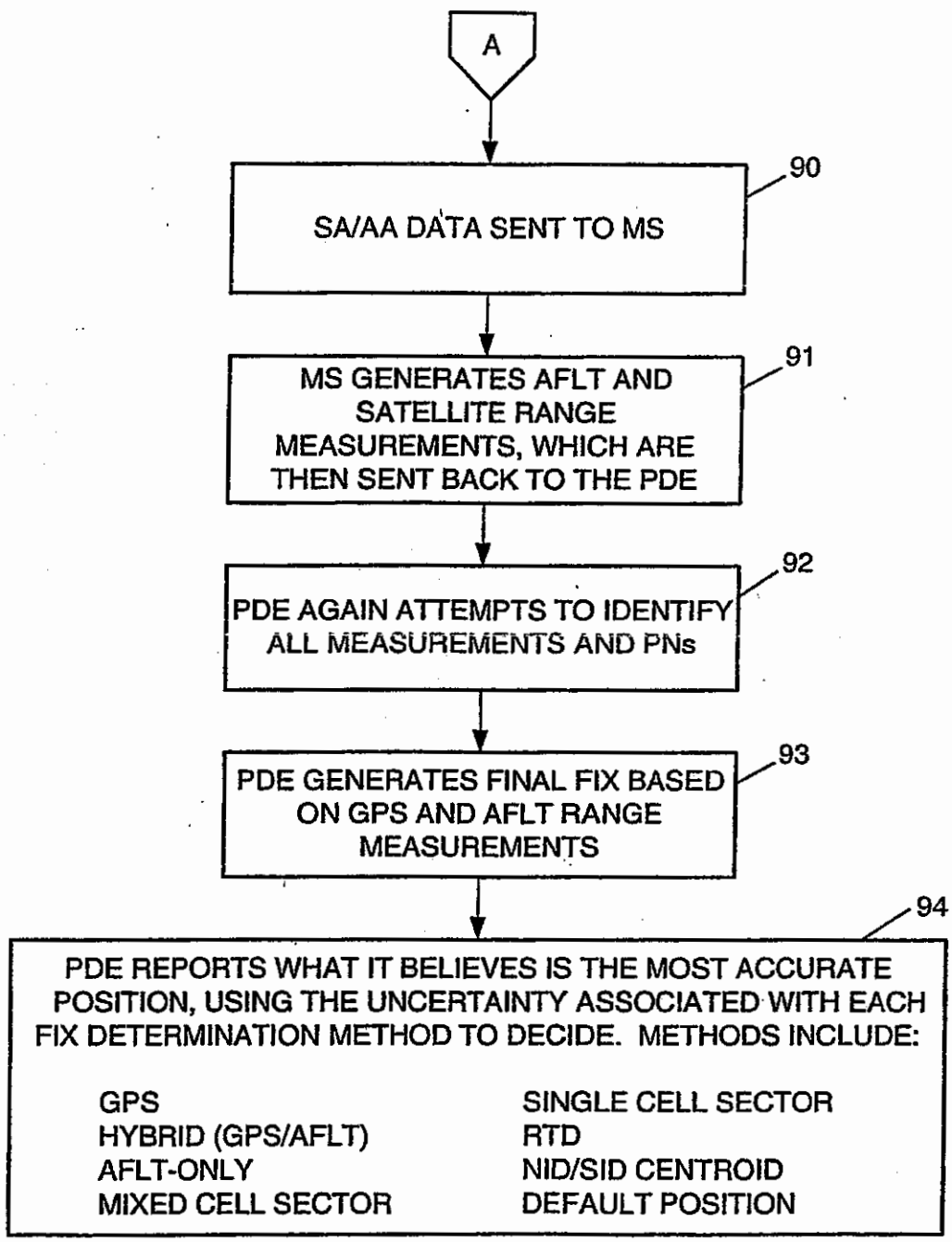

A
SA/AA DATA SENT TO MS
90
MS GENERATES AFLT AND SATELLITE RANGE MEASUREMENTS, WHICH ARE THEN SENT BACK TO THE PDE
91
PDE AGAIN ATTEMPTS TO IDENTIFY ALL MEASUREMENTS AND PNs
92
PDE GENERATES FINAL FIX BASED ON GPS AND AFLT RANGE MEASUREMENTS
93
94
PDE REPORTS WHAT IT BELIEVES IS THE MOST ACCURATE POSITION, USING THE UNCERTAINTY ASSOCIATED WITH EACH FIX DETERMINATION METHOD TO DECIDE. METHODS INCLUDE:
GPS
HYBRID (GPS/AFLT)
AFLT-ONLY
MIXED CELL SECTOR
SINGLE CELL SECTOR
RTD
NID/SID CENTROID
DEFAULT POSITION

FIG. 9

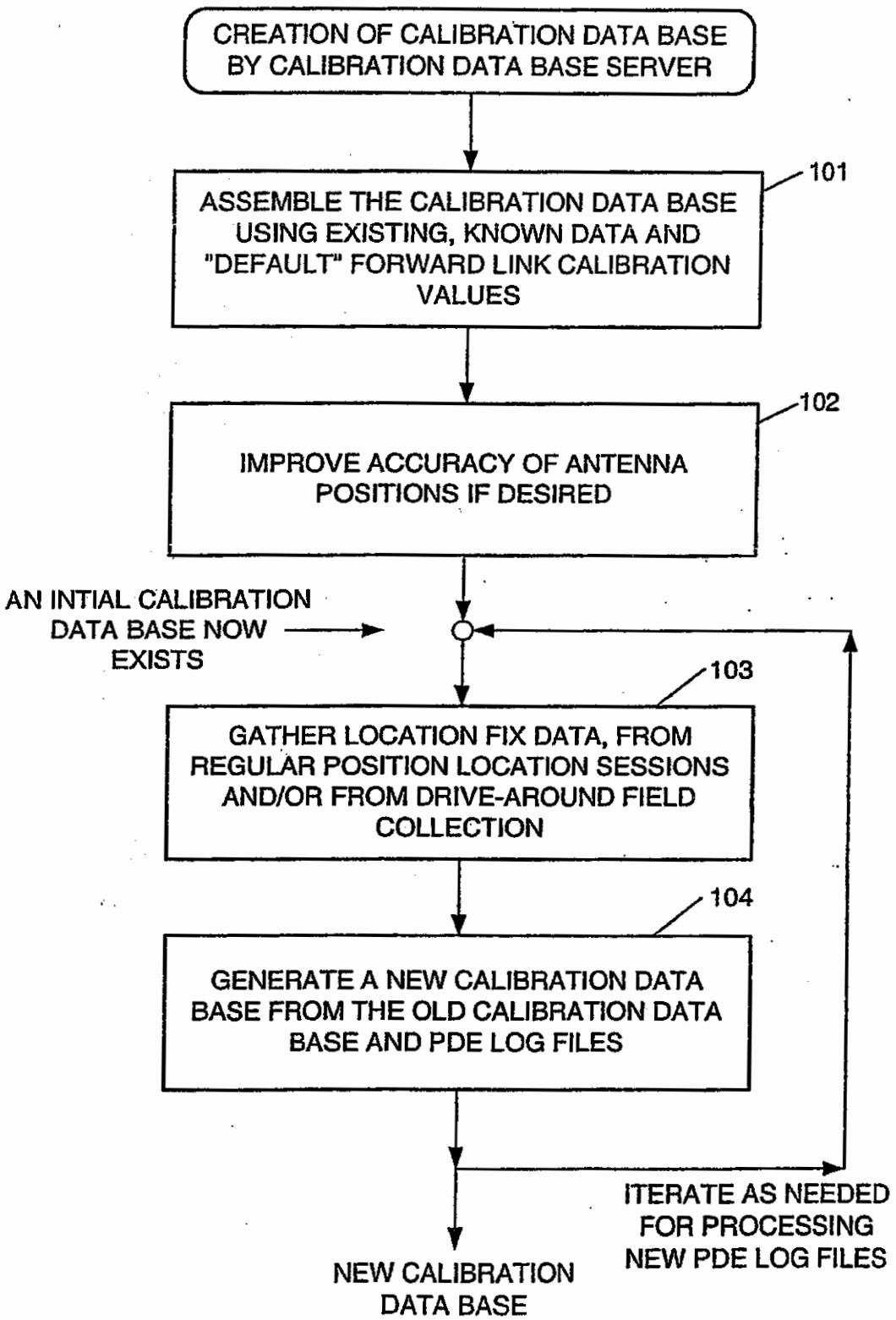

CREATION OF CALIBRATION DATA BASE BY CALIBRATION DATA BASE SERVER
ASSEMBLE THE CALIBRATION DATA BASE USING EXISTING, KNOWN DATA AND "DEFAULT" FORWARD LINK CALIBRATION VALUES
101
IMPROVE ACCURACY OF ANTENNA POSITIONS IF DESIRED
102
AN INTIAL CALIBRATION DATA BASE NOW EXISTS
GATHER LOCATION FIX DATA, FROM REGULAR POSITION LOCATION SESSIONS AND/OR FROM DRIVE-AROUND FIELD COLLECTION
103
GENERATE A NEW CALIBRATION DATA BASE FROM THE OLD CALIBRATION DATA BASE AND PDE LOG FILES
104
ITERATE AS NEEDED FOR PROCESSING NEW PDE LOG FILES
NEW CALIBRATION DATA BASE

FIG. 10

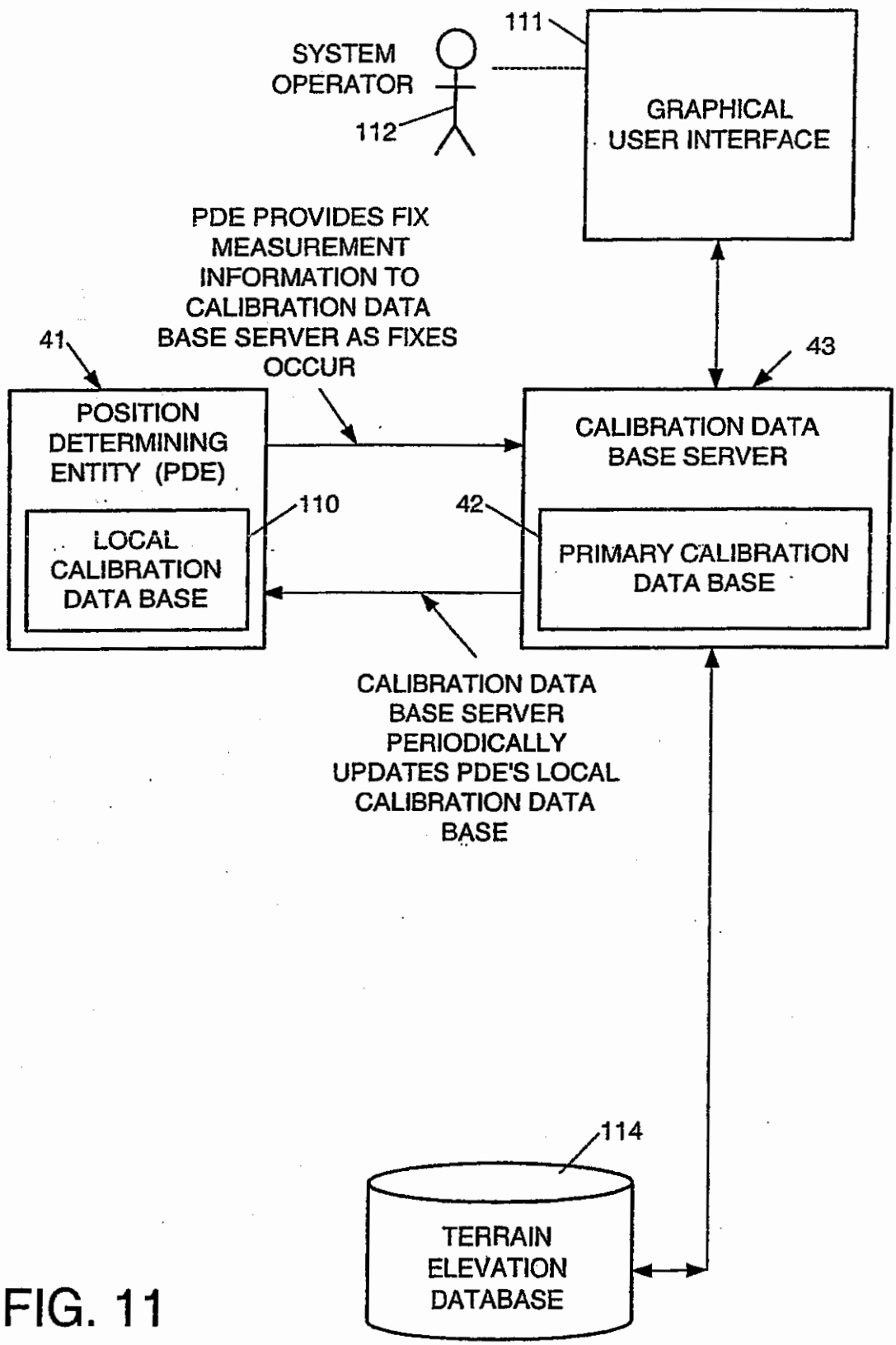

111
SYSTEM OPERATOR
112
GRAPHICAL USER INTERFACE
PDE PROVIDES FIX MEASUREMENT INFORMATION TO CALIBRATION DATA BASE SERVER AS FIXES OCCUR
41
43
POSITION DETERMINING ENTITY (PDE)
110
LOCAL CALIBRATION DATA BASE
42
CALIBRATION DATA BASE SERVER
PRIMARY CALIBRATION DATA BASE
CALIBRATION DATA BASE SERVER PERIODICALLY UPDATES PDE'S LOCAL CALIBRATION DATA BASE
114
TERRAIN ELEVATION DATABASE

FIG. 11

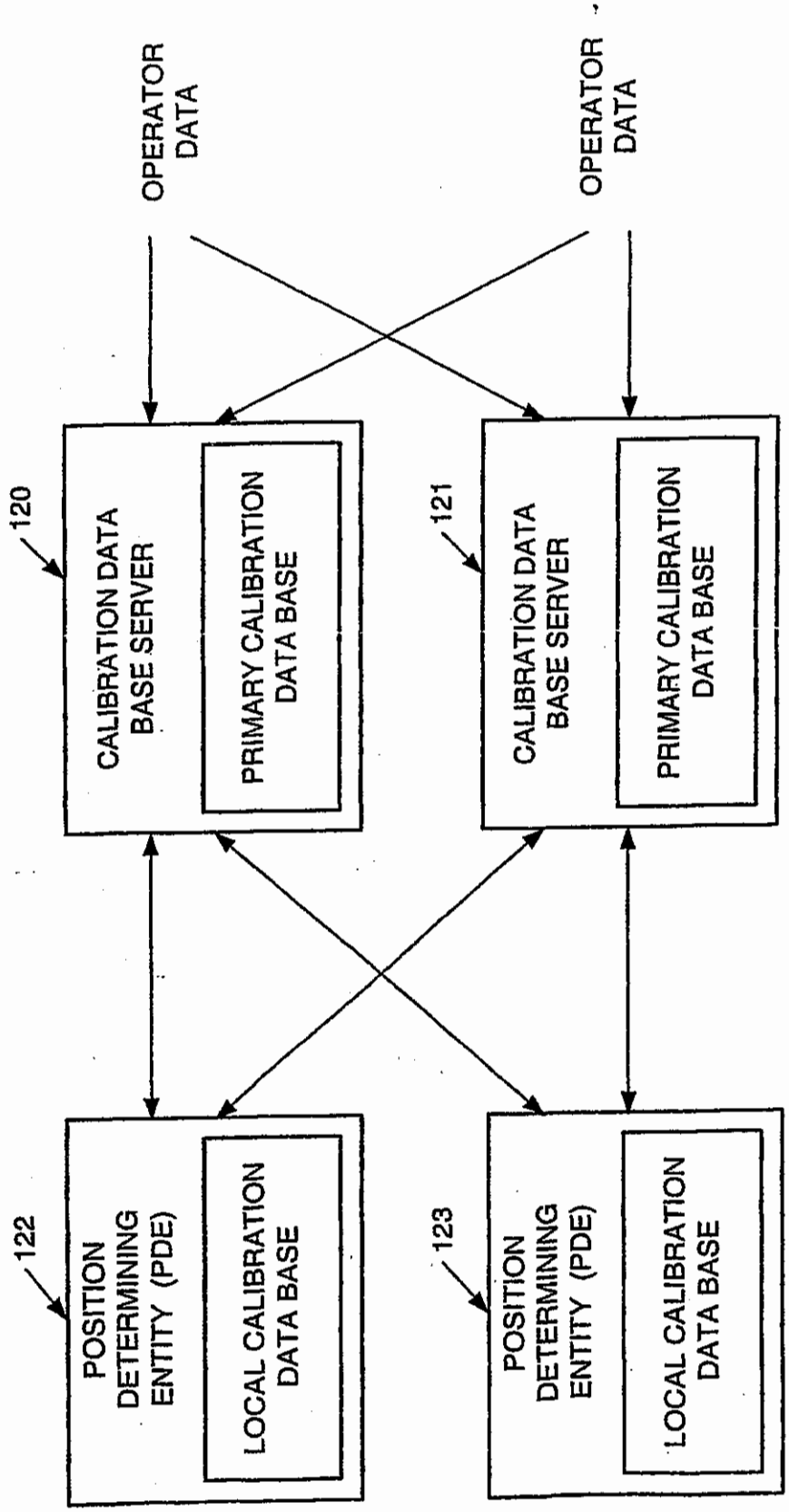

OPERATOR DATA
OPERATOR DATA
120
CALIBRATION DATA BASE SERVER
PRIMARY CALIBRATION DATA BASE
121
CALIBRATION DATA BASE SERVER
PRIMARY CALIBRATION DATA BASE
122
POSITION DETERMINING ENTITY (PDE)
LOCAL CALIBRATION DATA BASE
123
POSITION DETERMINING ENTITY (PDE)
LOCAL CALIBRATION DATA BASE

FIG. 12

BSA Field Groups
Cell Sector Identify Information (in IS-95: Network ID, System ID, Switch Number, Extended Base Station ID, plus PN)
Pilot Sector Name
Antenna Position - Latitude, Longitude, and Altitude (height above ellipsoid)
Cell Sector Centroid Position - Latitude, Longitude, and Altitude (Height above ellipsoid)
Antenna Orientation
Antenna Opening
Maximum Antenna Range (MAR)
Terrain Average Height
RTD Calibration
FWD Link Calibration
Potential Repeater
PN Increment
Uncertainty Parameters

FIG. 13

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
Cell Sector Identity Information (in IS-95: Network ID, System ID, Switch Number, Extended Base Station ID, plus PN)	Identity information is the key to relating signals observed by a handset to information in the calibration data base. Identity information in particular must be complete and accurate, and must be free of duplication or error for good location determination performance. New or modified cellular infrastructure or cellular infrastructure configuration changes, result in identity changes. Such changes are frequent.	• Spot all instances where an identity observed by a handset is not found in the calibration data base. Track such occurrences over time. • Identify *new* sectors added to the network. Advise operator. Generate a calibration data base entry including determination of the antenna location, the observed identity, calibration and uncertainty parameters calculated automatically, and default values. • Identify sectors whose identity observed by the handset or reported by the cellular infrastructure has changed due to a network change or reconfiguration and no longer matches the calibration data base. Automatically alter the calibration data base to reflect the new identity.

FIG. 14

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
Antenna Position – Latitude, Longitude, and Altitude (height above ellipsoid)	For terrestrial range measurements, antenna position helps the PDE to resolve the reference sector and measurement sector identities, and is the location from where the range measurements originate. Antenna position errors translate into terrestrial range errors. Antenna position is also essential in generating an "initial position estimate", which is used to generate GPS assist information.	• Identify calibration data base sector antenna positions that are not consistent with the measured position. This can result from mobile cells (COWs and COLTs) or from calibration data base typos. Advise operator. If so configured, automatically fix.

FIG. 15

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
Cell Sector Centroid Position – Latitude, Longitude, and Altitude (height above ellipsoid)	Sector centroid position is returned as the result when more accurate location determination methods fail. Also, sector centroid position is also essential in generating an "initial position estimate", which is used to generate GPS assist information. The cell sector centriod is one of the parameters that helps the PDE understand the sector coverage area. Knowledge of the sector coverage area is key to successfully relating observed terrestrial signals to an entry in the calibration data base.	• Map the sector coverage area and thus the most optimal cell sector centroid position over time. Update calibration data base as needed.

FIG. 16

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
Antenna Orientation	The direction the cell sector antenna is pointed. Antenna orientation is often used to determine the approximate sector coverage region and sector centroid position with off-line tools.	• Map the sector coverage area and thus the most optimal Antenna Orientation over time. Update calibration data base as needed.
Antenna Opening	Antenna opening (beam width) is often used to determine the approximate sector coverage region and sector center position with off-line tools.	• Map the sector coverage area and thus the most optimal Antenna Opening over time. Update calibration data base as needed.
Maximum Antenna Range (MAR)	Maximum Antenna Range is the key parameter used by the PDE to quantify the sector coverage area. Knowledge of the sector coverage area is key to successfully relating the observed terrestrial signal to an entry in the calibration data base.	• Map the sector coverage area and thus the most optimal MAR over time. Update calibration data base as needed.

FIG. 17

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
Terrain Average Height	Terrain average height is required with AFLT because without a height constraint, AFLT fixes could drift wildly. Also knowledge of height allows one few measurement to come from a range measurement, which can greatly improve location fix availability.	• Generate Terrain Average Height using an altitude database. • Track the heights returned from location fixes with low uncertainties. Correct the Terrain Average Height in the calibration data base as required, and automatically set terrain standard deviation to reflect the distribution of actual fixes.

FIG. 18

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
RTD Calibration	RTD calibration is intended specifically to improve the accuracy of reverse-link AFLT range measurements.	• Automatically improve *RTD calibration* and *RTD calibration accuracy* over time using real user measurements.
FWD Link Calibration	Forward link calibration is intended specifically to improve the accuracy of forward-link terrestrial AFLT range measurements in IS-95 CDMA systems. Forward link calibration errors translate into AFLT Range measurement errors, which translate into fix errors.	• Automatically improve *forward link calibration* and *forward link calibration accuracy* over time using real user measurements.

FIG. 19

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
Potential Repeater	If a repeater is used and the PDE does not know about it, AFLT range measurements can be wildly wrong, and the AFLT algorithm becomes unstable. For this reason, any sector identity with a repeater used must be noted in the calibration data base.	• Detect the presence of an un-noted repeater. Make appropriate fixes to the calibration data base. • Track how frequently each noted repeater is observed. Remove the repeater use flag or advise an operator if a repeater is believed not to exist.
PN Increment	PN increment helps the PDE to correctly resolve the PN offset numbers of distant base stations. Since it is so easy to know, there is no reason not to include it.	• Detect PN increment inconsistency between what is observed over the air and what is in the calibration data base. If inconsistent, fix.

FIG. 20

Calibration Data Base Field Group	Description	Problem Detection Methodology / Calibration Data Base Server Function Using this Parameter
Uncertainty Parameters	Uncertainty parameters, such as "antenna location accuracy", "terrain height standard deviation", "RTD calibration accuracy", and "FLC accuracy" give bounds to their respective calibration data base parameters and allow the PDE to construct an overall uncertainty to the range measurements that uses these parameters, and thus an error estimate for the final position fix.	• When highly accurate final location fixes are available, use this knowledge to assess the uncertainty of the terrestrial range measurements seen in these fixes. Allocate this uncertainty to the uncertainty parameters that were used to construct each range. Automatically update uncertainty parameters once a sufficient number of samples exist to establish confidence in the new values. Track changes over time, making updates as needed.

FIG. 21

PROBLEM DETECTION METHODS THAT USE AN ESTIMATE OF THE CELLULAR HANDSET'S POSITION
INVERSE SECTOR ANTENNA POSITIONING
FORWARD LINK CALIBRATION AND RTD CALIBRATION
RESOLVING INCORRECT SECTOR IDENTITY IN THE PDE
SPOTTING THE PRESENCE OF REPEATERS
SPOTTING NEW OR MOVED SECTORS
DETERMINING UNCERTAINTY PARAMETERS
PROVIDING CELLULAR COVERAGE MAPS & DIAGNOSTIC INFORMATION
PROVIDING FEEDBACK TO USERS ABOUT CELLULAR SYSTEM OR LOCATION PERFORMANCE.

FIG. 22