

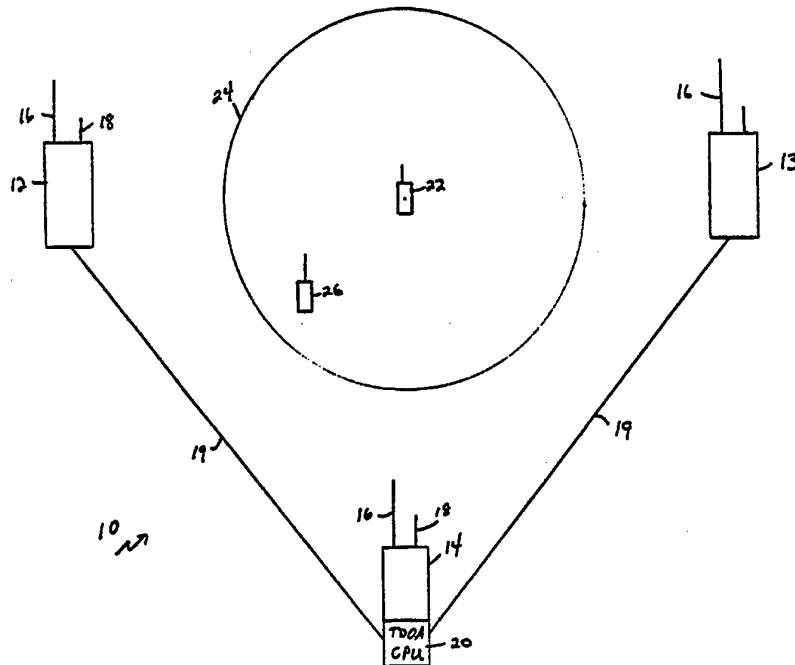


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(54) Title: APPARATUS AND METHOD FOR LOCATING CELLULAR TELEPHONES AND SIMILAR TRANSMITTERS



(57) Abstract

The field of locating cellular telephones suffers from high multipath city environments which affect accuracy. This problem can be overcome by a two tiered approach including a general location determination using cellular base station located system (10) and subsequent finite location using a portable receiver (26) capable of functioning in high multipath environments. Applications include emergency calls and criminal investigations.

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**APPARATUS AND METHOD FOR LOCATING CELLULAR TELEPHONES  
AND SIMILAR TRANSMITTERS**

5

**Background of the Invention**

**Field of the Invention**

The present invention generally relates to the function of locating cellular telephones and other mobile transmitters, and particularly, to a method and apparatus which use a two stage approach including a long range, variable accuracy technique in combination with a short range, high accuracy technique.

**15 Statement of the Prior Art**

The proliferation of cellular telephones, or cell phones, and their technology and usage, has revealed various applications for the ability to locate cell phones and similar transmitters. These applications include "911" calls, tourist and travel information, the tracking of commercial, government and stolen vehicles, and the identification of unauthorized cell phone usage and illegal activities, to name a few. The basic cell phone systems can only determine the nearest cell phone base station, which locates the cell phone to within 3 to 10 miles.

A goal of any such system for use with cellular phones is the use of as much existing equipment as possible or at least compatibility with existing equipment. Examples of this are use with unmodified cellular phones and compatibility with existing cellular base stations.

A great deal of technology already exists concerning the tracking or locating of radio transmitters. One

least in such applications as LORAN and GPS. The application of this process to cell phones includes accurately measuring the time of arrival of the same signal at a multiplicity of base stations and comparing  
5 the times to determine the difference between transmission times to each base station. Tdoa techniques do not require any modifications of the transmitters, because they operate on the ordinary signal transmitted. Tdoa techniques are also compatible with existing  
10 omnidirectional cell phone, base station antennas.

One such application of tdoa technology combined with direction finding and applied to cellular phones is described in US Patent No. 5,317,323. The system described therein uses GPS timing signals at the  
15 receivers to determine the time of signal reception. Direction finding is used to reduce multipath and co-channel interference. Unfortunately, the use of direction finding requires the use of a steerable antenna or array and is thus not compatible with the existing  
20 omnidirectional antenna structures used in the cell phone industry. Even sectorized antennas, which may be used for cell phones, do not provide sufficient accuracy. The patent does show the importance of removing multipath interference. Thus, it is a goal of any such locating  
25 system for cellular telephones to distinguish between a direct signal from a cell phone and multipath reflections of the same signal from buildings and other reflectors. Reflected signals, which take a longer and unknown path to the receiver, provide less accurate location  
30 information.

A similar approach to locating cell phones is described in US Patent No. 5,327,144. This approach employs tdoa techniques by collecting all data transmitted by cell phones on the reverse control channel

and cross correlating that data to identify and locate those cell phones. This approach demonstrates an inherent deficit in using the tdoa technique alone with unmodified cell phones in that the signal which is being  
5 measured is limited to a 30 KHz transmission channel. This limited bandwidth limits the accuracy of the tdoa measurement under ideal conditions to a theoretical 300 feet. Whenever any sort of multipath or co-channel interference is encountered, this accuracy deteriorates  
10 significantly.

#### SUMMARY OF THE INVENTION

Accordingly, it is a object of the present invention to provide an apparatus and method for determining the  
15 location of cellular telephones and similar transmitters which provides a high degree of accuracy.

It is a further object of the present invention to perform such location finding on ordinary cell phones and similar transmitters which are not specially modified.

20 It is still a further object of the present invention to perform such location finding in the presence of high levels of multipath reflected signals.

It is yet a further object of the present invention to perform such location finding using antennas and  
25 antenna structures which are normally used for typical cell phone operation.

In one embodiment, the present invention provides a method for determining the location of a cellular telephone or similar transmitter, comprising the steps of  
30 determining the general location of the phone or transmitter within a predetermined range by receiving transmissions thereof at a plurality of locations and signal processing the received signals, receiving transmission signals from the phone or transmitter with a

portable receiver located within the predetermined range of the phone or transmitter, and determining the precise location of the cell phone or transmitter in response to the transmission signals received by the portable  
5 receiver.

In another embodiment, the present invention provides an apparatus for determining the location of a cell phone or similar transmitter, comprising means for determining the general location of the phone or  
10 transmitter within a predetermined range thereof including means for receiving transmissions therefrom at a plurality of locations and means for signal processing the received signals, and portable receiver means adapted for movement to within the predetermined range of the  
15 phone or transmitter for receiving transmission signals from the phone or transmitter and including means for determining the precise location of the cell phone or transmitter in response to the received transmission signals.

20

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustratively described in reference to the appended drawings in which:

Fig. 1 is a system block diagram of an apparatus  
25 constructed in accordance with a portion of one embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE DRAWINGS

Fig. 1 shows one embodiment of a cell phone locating  
30 system 10 which would take advantage of existing cell phone base stations and antennas. System 10 generally includes a multiplicity of existing cellular base stations 12-14, to which apparatus of the present invention is added. Base stations 12-14 make use of

existing transmit and receive antennas 16 which may be identical in form and function. Added to each base station is an additional GPS (Global Positioning System) antenna 18 which receives timing signals from the  
5 existing civilian GPS for use in the locating function.

Each of the base stations includes further equipment for performing the locating function. This equipment generally includes means for sampling or digitizing the signals received from the cell phone or transmitter 22  
10 and time stamping the resulting data with signals derived from the received GPS signal.

Communication lines 19 are shown connecting at least two remote base stations 12,13 with a central base station 14. Central base station 14 includes equipment  
15 not present in the remote base stations 12,13 in the form of tdoa CPU 20 for processing signals received by all base stations 12-14. Tdoa CPU 20 may be located at any one of the base stations or may be located separately from such base stations. Such separate location would  
20 include the interconnection of all comm. lines 19 directly between the base stations and tdoa CPU 20.

Tdoa CPU 20 receives the digitized, time stamped data from each of the receiving base stations and cross correlates similar data. The time stamps on the  
25 correlated data thereupon provide time difference of arrival data between the correlated data and the corresponding base stations, which have known locations. The general location of cell phone or transmitter 22 may then be determined in accordance with well known  
30 techniques.

The tdoa system described above provides a means for determining a general location of a cell phone or similar transmitter 22 within a predetermined range represented by circle 24. This general location function may be

provided by any other suitable technique such as direction finding. One acceptable tdoa method is described in US Patent Application Number 08/272,725 filed July 8, 1994 for APPARATUS AND METHOD FOR LOCATING  
5 CELLULAR TELEPHONES by the same inventor hereof, the contents of which are hereby incorporated by reference herein.

Once the general location of circle 24 is known, a portable receiver 26 may be transported to that area and  
10 used for precisely locating the phone or transmitter 22. Where a local police force carries the portable receiver in a number of patrolling police cars, such a portable receiver may already be located within the general location of circle 24. The size of circle 24 technically  
15 depends upon the accuracy of the location equipment described above. However, it is much more practical if the size of circle 24 is commensurate with the receiving capability of the portable receiver 24. Due to the limited elevation of the portable receiver 26, terrain  
20 will have an impact upon receiver performance.

The portable receiver 26 may also be of any suitable type and make. One such type is described in US Patent Application No. 08/272,724, Filed July 8, 1994 entitled APPARATUS AND METHOD FOR FINDING A SIGNAL EMISSION SOURCE  
25 by David L. Herrick and William F. Matthews III, the contents of which are hereby incorporated by reference herein. The portable receiver in question uses relative movement between the receiver and the phone or transmitter 22 to determine the general direction  
30 thereof. The described technique is useful in high multipath environments such as buildings. Other forms of direction finding may also be suitable.

In order for the portable receiver 26 to accurately locate the cell phone or transmitter 22, it will be



necessary to determine the transmitting frequency of the phone or transmitter 22 and receive that signal. In the case of a cellular phone 22, the transmission frequency will depend upon a channel allocation from the local cell  
5 phone system. To determine the proper channel allocation it may be preferable to establish a communication link between receiver 26 and the local cellular system to receive the channel assignment.

The locating system thus provided overcomes any  
10 inaccuracies present in the long range system without requiring significant additional expense. Such inaccuracies may even be impossible to avoid in high multipath environments. The addition expense of a high accuracy system located in cellular base stations is  
15 significant given the number of operating base stations.

The embodiments described above are intended to be taken in an illustrative and not a limiting sense. Various modifications and changes may be made to the above embodiments by persons skilled in the art without  
20 departing from the scope of the present invention as defined in the appended claims.

**WHAT IS CLAIMED IS:**

1. A method for determining the location of a cellular telephone or similar transmitter, comprising the steps of:

5 determining the general location of the phone or transmitter within a predetermined range by receiving transmissions thereof at a plurality of locations and signal processing the received signals;

10 receiving transmission signals from the phone or transmitter with a portable receiver located within the predetermined range of the phone or transmitter; and

determining the precise location of the cell phone or transmitter in response to the transmission signals received by the portable receiver.

15

2. The method of claim 1, wherein the plurality of locations of transmission reception are base stations of a cellular telephone network.

20

3. The method of claim 2, wherein the predetermined range is determined by the reception capabilities of the portable receiver.

25 4. The method of claim 3, wherein the step of determining the general location is accomplished using time difference of arrival signal processing techniques.

30 5. The method of claim 1, further comprising the step of transporting the portable receiver to within the predetermined range of the phone or transmitter to be located.

6. The method of claim 1, wherein the step of determining the precise location includes measuring a

characteristic of the transmission signal received within the predetermined range while moving the portable receiver and moving the portable receiver in response to the measured characteristic.

5

7. An apparatus for determining the location of a cell phone or similar transmitter, comprising:

means for determining the general location of the phone or transmitter within a predetermined range thereof including means for receiving transmissions therefrom at a plurality of locations and means for signal processing the received signals; and

portable receiver means adapted for movement to within the predetermined range of the phone or transmitter for receiving transmission signals from the phone or transmitter and including means for determining the precise location of the cell phone or transmitter in response to the received transmission signals.

20 8. The apparatus of claim 7, wherein the plurality of locations of transmission reception are base stations of a cellular telephone network.

25 9. The apparatus of claim 8, wherein the predetermined range is determined by the reception capabilities of the portable receiver.

30 10. The apparatus of claim 9, wherein the means for signal processing includes a time difference of arrival algorithm.

11. The apparatus of claim 7, wherein the portable receiver means includes means for measuring a characteristic of the received signal during movement of

the receiver means for providing an indication of the direction of the precise location.

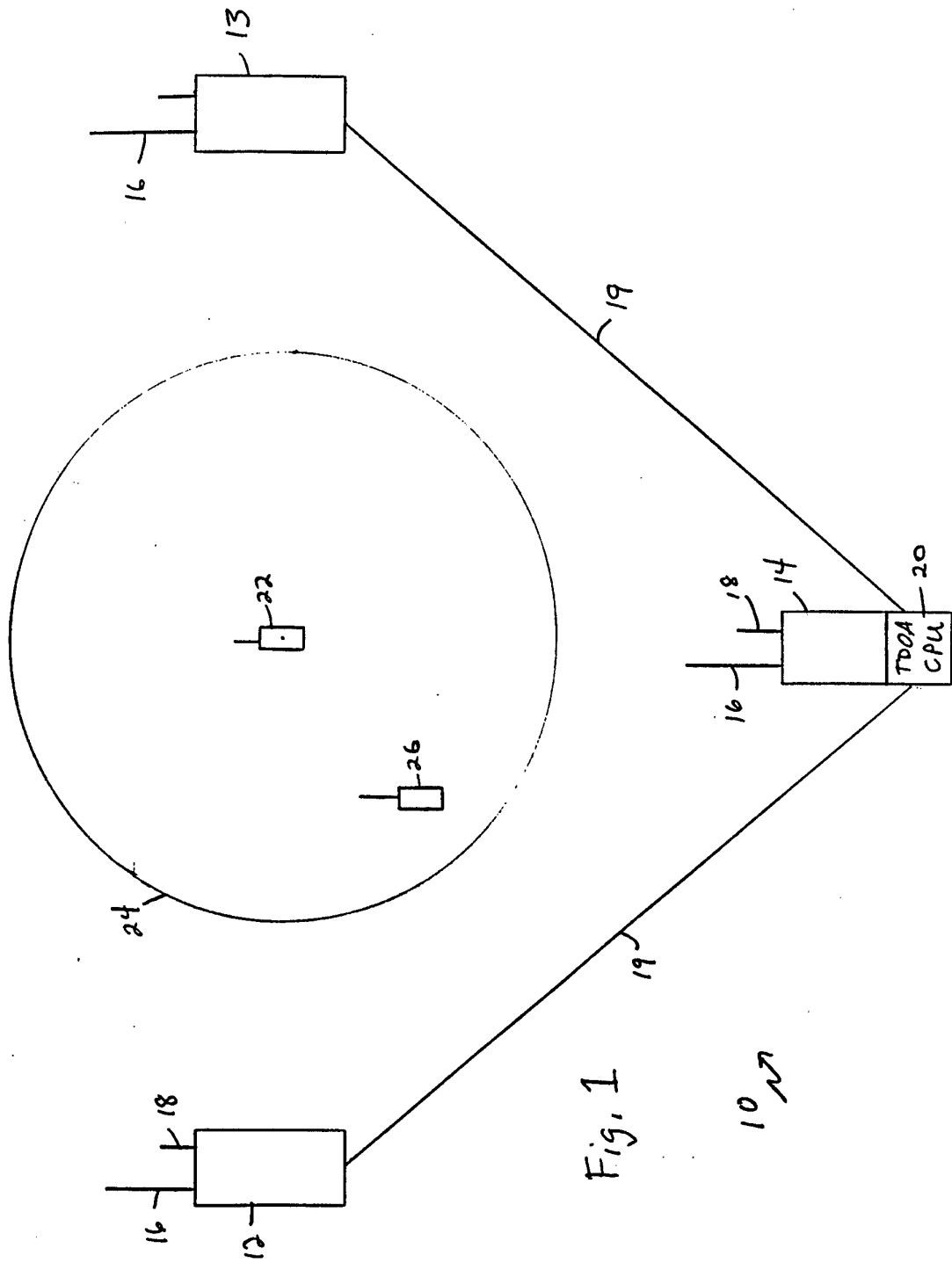


Fig. 1

10

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US95/08527

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G01S 1/24, 3/02; H04M 11/00

US CL : 342/387, 457, 458; 379/58

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. : 342/387, 457, 458; 379/58

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

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y, P	US, A, 5,343,493, (KARIMULLAH) 30 August 1994, col. 1, lines 9-11 and col. 7, lines 65-68.	1-11
Y	US, A, 5,327,144 (STILP ET AL) 05 July 1994, col. 13, line 30- col. 14, line 15.	1-11
Y	US, A, 5,003,317 (GRAY ET AL) 26 March 1991, col. 4, lines 19-25 and col. 8, lines 28-68.	1-11

 Further documents are listed in the continuation of Box C.
  See patent family annex.

* Special categories of cited documents:	"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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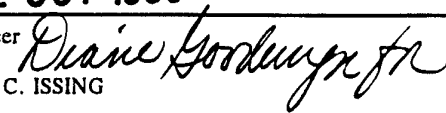
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