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[54] **MOBILE RADIO TRANSMISSION SYSTEM USING PREFERRED HOME SERVICE AREA**

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[30] **Foreign Application Priority Data**

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[51] Int. Cl.⁵ **H04Q 7/02; H04Q 9/02; H04B 17/02**

[52] U.S. Cl. **455/33.1; 455/54.2; 455/62; 379/60**

[58] Field of Search **455/33, 34, 52, 53, 455/54, 56, 62, 33.1, 33.2, 33.3, 34.1, 34.2, 52.1, 53.1, 54.1, 54.2, 56.1, 62; 379/58, 59, 60, 63**

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[57] **ABSTRACT**

A private mobile radio transmission system comprising a plurality of geographically spaced base stations (BS) defining a plurality of overlapping service areas (SA). The base stations are coupled for example by land-line communication links (CL) to a system controller (SC). Mobile stations (MS) equipped with simplex two-way radios are free to roam through the service areas. In order to be able to make a call with or via a base station it is necessary for the mobile station to be registered with the base station concerned. Details of the registration are stored by the mobile station concerned and the base station. In order to optimise on the usage of radio channels, details of a home base station are preprogrammed into each mobile station and when the mobile station wishes to register with a base station, it is instructed to try to register firstly with its own base station, on the basis that the majority of calls will be to and from the home service area and will require only one pair of frequencies, secondly with a base station of any other service area in its region, and thirdly with a base station of a service area in any other region. When registered with a service area other than its home one, the mobile station checks regularly to see if it is possible to register with its home service area.

17 Claims, 2 Drawing Sheets

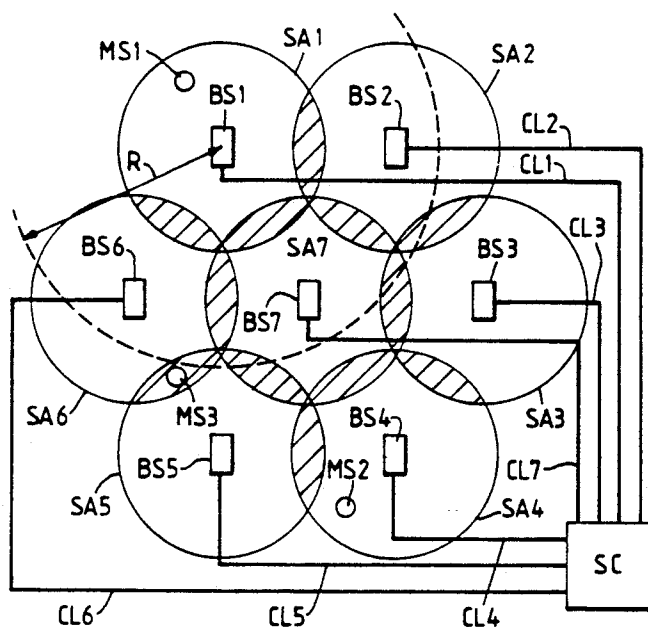


EXHIBIT
Ex. 1027

Fig. 1.

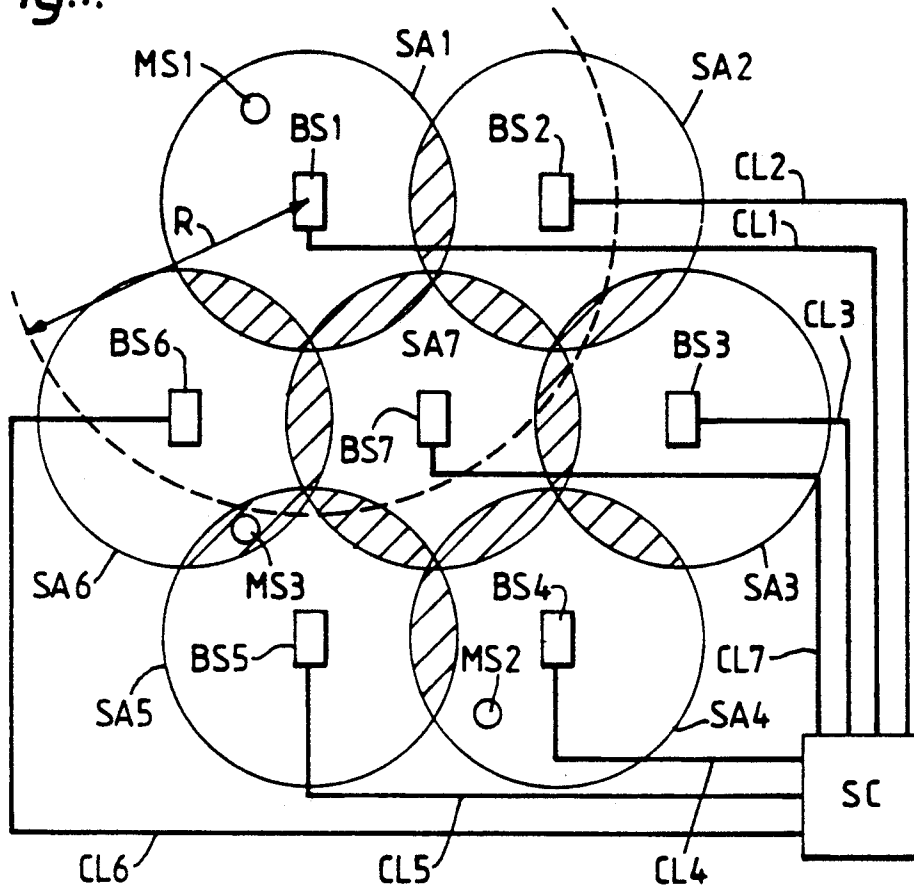


Fig. 2.

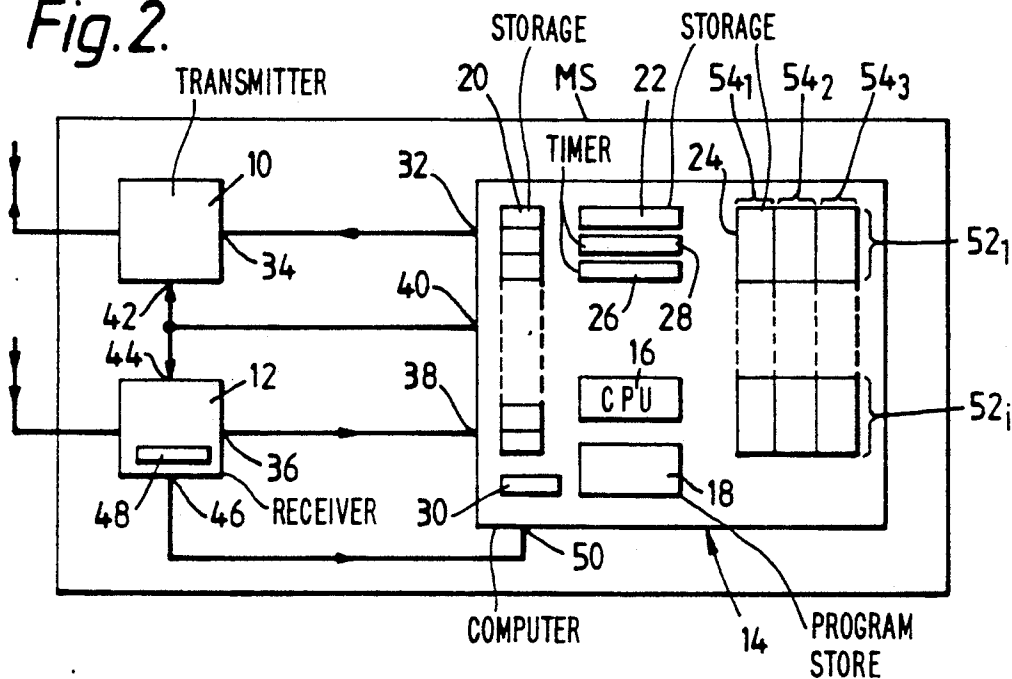


Fig. 3.

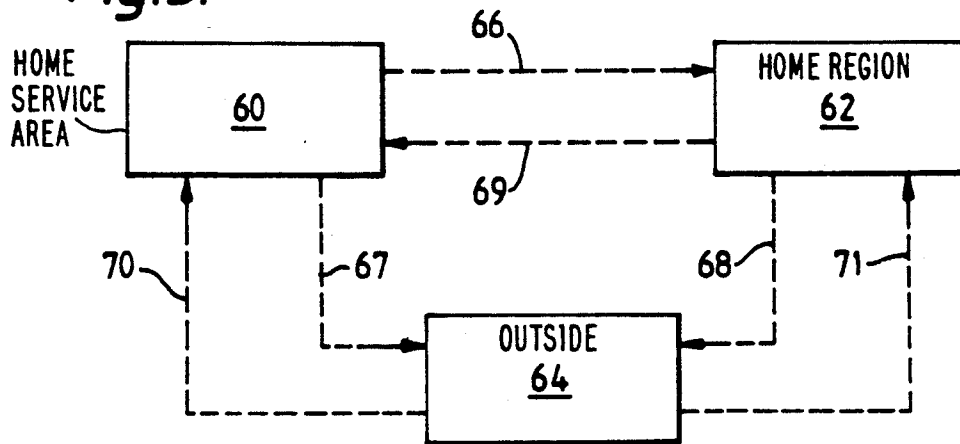
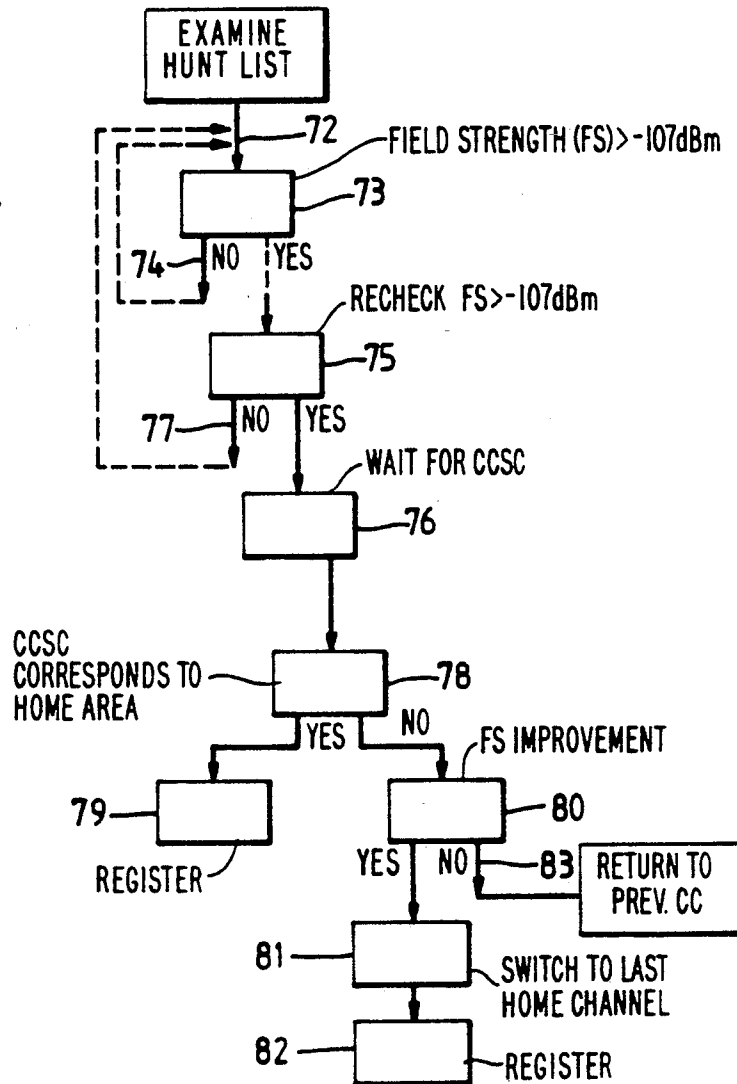


Fig. 4.



MOBILE RADIO TRANSMISSION SYSTEM USING PREFERRED HOME SERVICE AREA

BACKGROUND OF THE INVENTION

The present invention relates to a mobile radio transmission system and to a mobile station for use in the system.

Such a system typically comprises a plurality of base stations situated at respective geographical locations to define a plurality of service areas within an overall region and a plurality of mobile stations capable of communicating by two-way radio with each base station when in communication range of that base station. Each base station comprises the entirety of transmitters and receivers operated by a trunking system controller (TSC) at any one site or service area. The communication link established is two-frequency simplex, that is one frequency is allocated to forward transmission from a base station to a mobile station and a second frequency is allocated for return transmission from a mobile station to a base station. Blocks of radio channels chosen from an overall band of channels are allocated to each base station. In the case of trunked radio, the base stations of a region may be connected by way of land line to a control station (CS) or may be connected as a mesh with the base stations interconnected with each other. There may be two or more regions in which case each region has its own CS which controls a plurality of associated base stations. The CSs are connected together by land lines.

In a known such system each mobile station is arranged when operative to register with a base station of which it is within communication range and thereby with the corresponding service area, and to respond to it being no longer within communication range of a base station serving a service area with which it is currently registered by registering with another base station of which it is within such range (if any) and thereby with the corresponding service area. The base station responds to the registration request by storing the identity of the service area corresponding to the relevant base station in that one of its location records which corresponds to the registering mobile station. The registration procedure is carried out so that if it is desired to call a particular mobile station it is known in which service area that mobile station is currently located; the CS arranges that the call is directed to the or each base station which serves the relevant service area, which base station in turn calls the relevant mobile station. An advantage of a registration procedure is that if there was no provision for registration then all the base stations of the system would have to call the particular mobile station, which would impose a considerable overhead on the transmission capacity of the system. However, a disadvantage with this known registration procedure is that if a mobile station is roaming near a border between two or more service areas so that it frequently moves between areas it will frequently change its registration from one service area to another, again imposing a considerable overhead on the communication channel capacity of the system.

European Patent Specification EP-A2-0260763 discloses a multiple registration method aimed at reducing the transmission overhead associated with the above described system. This multiple registration method enables the TSC to store a list of up to n registrations for each mobile. The mobiles each have storage facilities

for storing the same list of registrations as are stored by the TSC in respect of itself. As a mobile enters a new service area it automatically registers with the area's base station thus updating the list of registration stored by the mobile and its associated TSC. By storing these registrations an enlarged service area is created. If a TSC wishes to contact a mobile it refers to the list of registrations which it is storing for that mobile and initially transmits a signal to the base stations which are registered, either successively, beginning with say the most recent registration, or simultaneously. If this is not successful then the TSC tries the other base stations. Provision is made for reordering the list on the basis that the channel number and frequencies of the service area in which a mobile last made a call are at the top of the list. In the event of the list of registrations not being updated and/or a call not being made to or received from a mobile after a set period then it is possible for registrations to be cancelled one at a time thereby reducing the size of the enlarged service area. While it is possible for all the registrations to be cancelled, it is preferred that at least one registration of a service area remain to prevent a flood of registrations at the start of a working day. If, at the start of a working day, a mobile is not registered in the service area in which it is currently located it has to arrange to immediately register. This method is quite workable but does have a drawback in that it will not necessarily optimise the usage of radio channels.

This drawback will be better understood by considering a hypothetical case of a circular geographical region of about 128 km with 7 base stations serving it. Obviously hilly areas tend to mask some mobiles from some base stations, and the signal strength obtained by a mobile from a base station varies inversely with the distance to the base station. The propagation map allows a generous margin of signal strength so that most mobiles can "see" most base stations.

The frequencies currently used in Great Britain for trunked private mobile radio systems are around 200 MHz, which are very penetrating and give good coverage, especially since the mobiles are extremely sensitive.

The power and number of radio channels fitted per base station are carefully chosen to correspond to the expected activity local to that base station.

The radio protocol used, for example a subset of MPT 1327-A Signalling Standard for Trunked Private Land Mobile Radio Systems issued by the Department of Trade and Industry, London 1988, effectively requires the mobiles to hold on to a registration as long as they can. The intention is, of course, to reduce the overhead of registration signalling on the network, which supplies no calls to the user.

Furthermore, the MPT 1327 protocol has a good error-correction layer, and so a significant number of on-air bits can be lost before any particular signalling packet fails. In consequence a mobile will not attempt to re-register on another base station unless the packet-level error rate on his present one is high. However on the fringe of the coverage area this can lead to a poor grade of service both in terms of speech signal-to-noise and in call set-up failure rate.

The result of the above set of circumstances is to change the radio topology of the network from being a number of largely isolated cells with little overlap, resulting in the registration map largely corresponding to the geographical position of the mobile, to one in which

the cells very greatly overlap, causing the registration map to be largely random. Each base station has a number of mobiles registered on it proportional to its radio coverage, and these mobiles are distributed over the part of the region in which this can be "seen". Each mobile has only a small chance of being registered on the base station where it is most likely for its calls to be satisfied by that base station alone, which base station may be regarded as the mobile's home site or home service area.

The effect of this is that a high percentage of calls say 80% are intersite calls, using 2 radio traffic channels per call instead of one, the system capacity is almost halved, and the number of calls each base station must support bears little relation to the carefully estimated local population on which its size and power were based. This means that a base station gets a load proportional to the size of its radio coverage, not the number of channels fitted. This has the potential of grossly overloading the smaller service areas. Creating more service areas within the region by adding more base stations actually makes things worse, since it means that each mobile's chance of being registered on its home site is proportionally reduced.

SUMMARY OF THE INVENTION

An object of the present invention is to optimise the usage of radio channels in a mobile radio transmission system.

According to one aspect of the present invention a radio transmission system comprises a plurality of base stations situated at respective geographical locations to define a corresponding plurality of overlapping service areas constituting one or more regions, and mobile stations capable of communicating by two-way radio with any one of the base stations. Each mobile station comprises a transmitter, a receiver, and control means for controlling the mobile station, and each mobile station is pre-programmed with details identifying a predetermined service area which is defined as its home service area. The control means is programmed to register the mobile station with its home service area in preference to any other service area provided that the signal quality between the home base station and the mobile station is acceptable.

The present invention is based on the realisation that most calls will be made between a mobile station and a despatcher who is fixed relative to the home base station or between two mobile stations who are registered with the home base station. Thus if a mobile station stays registered with the home base station for as long as possible and is instructed to return to the home base station whenever possible, then the likelihood of mobiles which are still within communication range of the home base station, even though they are out of its defined service area, being involved in mobile to mobile calls by way of two base stations and requiring 2 traffic channels is reduced. Thus one traffic channel is saved together with the overhead of signaling between base stations.

If desired, the control means of each mobile station may be programmed to hunt through the other service areas in its home region and attempt to register with one of them in the event of the mobile station not being able to register with its home service area.

In the event of a mobile being unable to register in its home region, the control means of a mobile station may be programmed to hunt through the service areas in

other regions and attempt to register with one of them in the event of the mobile station not being able to register with a service area in its home region.

The control means may be programmed to check the list of channels in its storage means and if it is not using the control channel assigned to its home service area, it checks to see if the home control channel can be received with adequate signal quality and if so the mobile station attempts to register with its home service area.

If desired, each base station may be instructed to transmit the number of its current control channel and control channels of other service areas and at the mobile station the control means may be programmed to check that the system identity codes received corresponds to the channel numbers stored for those service areas and if not it updates the numbers stored. Such a measure if implemented reduces the acquisition time and makes more accurate the mobile station's method of acquiring, if possible, its home site.

Each mobile station may store a parameter indicative of the signal quality of the respective control channels in the system, and in consequence the control means of a mobile station unable to register with its home service area may be programmed to take into account the signal quality as indicated by the parameter when seeking to register with another service area.

According to another aspect of the present invention a mobile station, for use with the radio transmission system in accordance with the first aspect of the present invention, comprises a transmitter, a receiver, control means for controlling the operation of the mobile station and means for assessing the quality of a received signal. The control means is pre-programmed with details identifying a predetermined service area which is defined as its home service area, and is programmed to register the mobile station with its home service area in preference to any other service area provided that the signal quality between the home base station and the mobile station is acceptable.

The present invention will be described, by way of example, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates diagrammatically the geographical layout of a hypothetical radio transmission system,

FIG. 2 is a block schematic diagram of an embodiment of a mobile station,

FIG. 3 is a flow chart of a registration procedure, and

FIG. 4 is a flow chart of an algorithm for implementing the channel hunting operation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawings the same reference numerals have been used to indicate corresponding features.

Referring to FIG. 1 the system comprises a plurality of base stations BS of which seven, BS1 to BS7, are shown, situated at respective geographical locations. Each of these base stations comprises an entirety of radio transmitters and receivers operated by a trunking system controller. The respective service areas SA1 to SA7 of these base stations overlap, as shown by the cross-hatching, to collectively cover the whole region shown. A plurality of mobile stations MS are provided of which three, MS1, MS2 and MS3 are shown. Each mobile station is free to roam throughout the whole region, and indeed outside it. Each of these mobile stations also comprises a radio transmitter/receiver

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