

CIRCUIT ARRANGEMENT FOR PROTECTING A CONTROL CHANNEL
FROM JAMMING WAVES IN A RADIO COMMUNICATION SYSTEM

This invention relates to a circuit arrangement for
use in a control station of a radio communication system and,
in particular, to a circuit arrangement for a control station
of a land mobile telephone system.

As will later be described with reference to one of
several figures of the accompanying drawing, a land mobile telephone
system generally comprises a control station comprising, in turn,
an exchange and a plurality of base stations, each having a ^{radio or} service
zone. The base stations are fixedly located at geographically
different sites so that the respective service zones may cover
a service area. Alternatively, each of the service zones may
be geographically independent of the others. A plurality of land
mobiles, namely, automobiles may be present in a service zone
of a base station accompanied by the exchange. The automobiles
thus serve as substations comprised by the land mobile telephone
system. Some of the substations are communicable with the other
subscribers through the base station under consideration. The

substations are also communicable with other substations in another service zone through the control station. Depending on the circumstances, no substation may be present in the service area.

A plurality of speech channels and a ^{few} control channels are allotted to each zone. The control channel comprises a paging channel for selectively calling up automobiles in the service zones. The paging channel is common to a plurality of the service zones. Therefore, the whole of the system is adversely affected when the paging channel is locally interrupted or suspended by any jamming or interfering waves.

This means that occurrence of jamming waves should be monitored and detected anyway to favorably operate the control system without any interruption.

In order to detect the jamming waves, a conventional system has measured an intensity of electric field during an idle or unused period, such as at night or the like, of the system. However, it is impossible for this conventional system to find out temporary jamming waves and to rapidly recover the system from interruption.

In another conventional control system, the intensity of electric field ^{of a test signal} is periodically measured during operation of the system. With this system, communication should, however, be periodically interrupted intermittently for the purpose of measuring the field intensity.

In both of the conventional systems, no automobile is communicable with a base station in the service area on occurrence of jamming waves ^{for a long time}.

It is an object of this invention to provide a circuit arrangement for use in a control station of a radio communication system, wherein jamming waves can be always monitored without interruption of communication.

It is another object of this invention to provide a circuit arrangement of the type described, which is operable even when a control channel is suspended by jamming waves.

A circuit arrangement to which this invention is applicable is for use in a control station of a radio communication system comprising a plurality of substations each of which is communicable with the control station through radio channels comprising a control channel and a plurality of speech channels. The control channel comprises a down and an up control channel. The down control channel is for supplying the substations with a set of control signals produced in the control station and comprising first and second control signals among which the second control signals are for requesting the substations not to answer the second control signals. The first control signals are for requesting selected ones of the substations to produce answer signals with time intervals left between the answer signals. The up control channel is for successively transmitting the answer signals to the control station from the selected substations. In a preferred embodiment of the invention to be described there is provided a circuit arrangement which comprises defining means for defining a time interval between two adjacent answer signals to produce a gate pulse lasting during a first pre-determined period when the _____

each time interval is not shorter than the first predetermined period and measuring means coupled to the defining means and the

second control channel for measuring the intensity of electric

(Of the answer signals transmitted through said up control channel, field during the first predetermined period to detect occurrence

(in the up control channel)
of the jamming waves.

Embodiments of the invention will now be described, by way of example, together with an arrangement to which the invention may be applied with reference to the accompanying

Fig. 1 schematically shows a plurality of service zones *drawings in which:-* of a land mobile telephone system to which this invention is applicable;

Fig. 2 shows a schematic block diagram of a circuit arrangement according to a first embodiment of this invention;

Fig. 3, drawn below Fig. 1, is a time chart for describing operation of the circuit arrangement illustrated in Fig. 2;

Fig. 4 is a schematic block diagram of a circuit arrangement according to a second embodiment of this invention; and

Fig. 5, depicted on the right side of Fig. 1, shows a flow chart for describing *the* operation of an automobile cooperating with the circuit arrangement illustrated in Fig. 4.

Referring to Fig. 1, a land mobile telephone control system to which this invention is applicable will be described at first for a better understanding of this invention. The illustrated system comprises first, second, and third base stations 11, 12, and 13 each of which is geographically separated from the others. The first, the second, and the third base stations 11, 12, and 13 have first, second, and third service zones 16, 17, and 18, respectively, which cover a service area. The first through third base stations 11, 12, and 13 are connected to *(a control station including)* an exchange (not shown in this figure). A combination of the base stations and

the exchange. is called a control station in the instant specification.

The system comprises a plurality of substations, namely, automobiles 19 (typically depicted as a single automobile) each of which is communicable with the base stations 11, 12, and 13 through radio channels comprising control channels and a plurality of speech channels. As control channels, provision is made of paging and access channels, as will later be described. More particularly, the illustrated first, the second, and the third base stations are provided with the speech channels depicted at $S_1, S_2, S_3; S_4, S_5, S_6;$ and S_7, S_8, S_9 , respectively, and with the access channels depicted at A_1, A_2 , and A_3 , respectively. The paging channel depicted at PC is common to all service zones.

At any rate, a pair of the ^{*} paging and the access channels are allotted as a control channel to each of the base stations 11, 12, and 13 in addition to a plurality of speech channels. For brevity of description, it will be assumed that the automobiles 19 in question are running in the first service zone 16 and is directly communicable with the first base station 11. Consideration is, therefore, mainly made on the automobiles 19 in the first service zone 16 by way of example. Similar consideration is also possible on any other automobiles in the remaining service zones.

Let the automobiles 19 in the first service zone 11 be selectively called up from the first base station 11. In this case, the paging channel PC is used as the control channel. The paging channel PC comprises a down paging channel directed from the base station 11 to the automobiles 19 and an up paging channel directed from the automobiles 19 to the base station 11. The down paging channel is used to supply the automobiles 19 with

a set of control signals produced in the ^(control station) ~~base station 11~~. The control signals are classified into first control signals for requesting the automobiles 19 to produce answer signals and second control signals for requesting the automobiles 19 not to produce the answer signals, as will become clear as the description proceeds.

The up paging channel is for ~~successively~~ transmitting the answer signals to the first base station 11 ^(each of) from the automobiles 19 at which the answer signals are produced. It should be noted here that the answer signals ^(successively) are received by the first base station 11 with time intervals left between the answer signals.

In order to selectively call up the automobiles 19 in the first service zone 16, paging signals are broadcast as a part of the first control signals through the down paging channel from the first base station 11 and also from the second and the third base stations 12 and 13 because some or all of the automobiles 19 may move to the second and/or the third service zones. Responsive to the paging signals, the called automobiles 19 return the answer signals back to the base station 11 through the up paging channel.

Supplied with the answer signals through the up paging channel, the ^(control station) ~~base station 11~~ produces channel assignment signals indicative of speech channels to be utilized by the automobiles 19 and ^(loop check) ~~announcement~~ signals indicative of information necessary to ^(confirmation of) connection of the automobiles 19 to the first base station 11. The channel assignment and the ^(loop check) ~~announcement~~ signals are delivered to the automobiles 19 through the down paging channel. No answer signal is produced from the automobiles 19 in response to the channel assignment and the ^(loop check) ~~announcement~~ signals. Thus, the channel assignment and ^(loop check) ~~announcement~~ signals serve as the second control signals.

Let a call originate with one of the automobiles 19.

In this case, the automobiles 19 produce identification code signals indicative of identification numbers for specifying called subscribers. The access channel is used to transmit the identification code signals and hence as the control channel in the case of call origination from the automobiles 19. Although various control operations are carried out by the use of the access channel, it may be understood throughout the instant specification that the access channel comprises an up access channel and a down access channel, like the paging channel.

It is to be noted here that the control channel including the paging channel and the access channel is common to a plurality of the automobiles 19. Therefore, the whole system is adversely affected by interruption of the control channel, as pointed out in the preamble of the instant specification.

Referring to Fig. 2, a circuit arrangement according to a first embodiment of this invention is used in a control station comprising three of the base stations 11, 12, and 13 and a single exchange 21. In Fig. ²~~1~~, each of the base stations 11, 12, and 13 comprises a paging channel transmitter 22 and a paging channel receiver 23, both of which are coupled to the paging channel PC illustrated in Fig. 1. More particularly, the transmitter 22 and the receiver 23 are operable in the down paging channel and the up paging channel, respectively, together with a duplexer 26 and an antenna 27. The paging channel receiver 23 comprises a limiter (not shown) for providing a limiter voltage dependent on an intensity of electric field in the up paging channel. The limiter is connected in a usual manner to a high frequency amplifier

or an intermediate frequency amplifier (not shown) in the receiver 23.

The circuit arrangement comprises a variable frequency oscillator 29 in each of the first through third base stations 11 through 13. The variable frequency oscillator 29 is connected to the limiter included in the control channel receiver 23 in order to produce a variable signal VR having a frequency variable with the limiter voltage. The variable signal VR is therefore variable in periods.

The exchange 21 further comprises a first portion 31 for the respective base stations, such as 11 and 12, and a second portion 32 common thereto.

Each of the first portions 31 comprises a gate circuit 33 for gating the variable signal VR in a manner to be described later, a counter 34 for counting a variable number of periods of the variable signal VR in unit time, and a comparator 36 for comparing the count with a reference value given by a reference circuit 37.

The second portion 32 comprises an exchange unit 41 comprising, in turn, speech path equipment and common control equipment both of which are well known in the art and not depicted. In addition to the exchange unit 41, the second portion 32 comprises a timing controller 42 for producing a sequence of timing pulses TM in a predetermined order, a down signal controller 43 for controlling the first and the second control signals in accordance with a program to send the same to the down paging channel, and a timer 44 operable in a manner to be described later. Further, an up signal controller 46 is connected between the respective paging

channel receivers 23 and the exchange unit 41 so as to control the answer signals supplied through the down paging channel.

Referring to Fig. 2 again and Fig. 3 anew, the exchange unit 41 produces the first and the second control signals (depicted at $AA_1, AA_2, \dots$; and $BB_1, BB_2, \dots$, respectively) in a usual manner. The down signal controller 43 controls the first and the second control signals to form a down control signal sequence DW in which the first and the second control signals are included in an order determined by the program.

The down control signal sequence DW is supplied from the down signal controller 43 under control of the timing controller 42 in a manner shown in Fig. 3.

More specifically, the down control signal sequence DW includes at least one of the second control signals $BB_1, BB_2, \dots$ interposed between two adjacent ones of the first control signals $AA_1, AA_2, \dots$.

Responsive to the down control signal sequence DW, the automobiles produce, through the up paging channel, an up control signal sequence (depicted at UP) including the answer signals depicted at $RP_1, RP_2, \dots$. It should be recollected that the first control signals $AA_1, AA_2, \dots$ request the automobiles 19 to produce the answer signals $RP_1, RP_2, \dots$ and that the second control signals $BB_1, BB_2, \dots$ request the automobiles not to produce the answer signals. Accordingly, the answer signals $RP_1, RP_2, \dots$ are produced in synchronism with the respective first control signals $AA_1, AA_2, \dots$. As shown in Fig. 3, quiescent periods of signals are left between two adjacent ones of the answer signals $RP_1, RP_2, \dots$ and are called time intervals. Each of the time

intervals are selected so that it is equal or longer than a first predetermined period T_a as will later be described. Briefly, each time interval is intentionally produced in the up paging channel UP by the use of the timing controller 42, as will become clear as the description proceeds.

Each of the answer signals $RP_1, RP_2, \dots$ is received by the base stations a delay period T_d after extinction of the corresponding answer signal and lasts during a prescribed period T_p following the delay period T_d . The total period defined by the delay period T_d and the prescribed period T_p is called a second predetermined period. Accordingly, it may be said that each of the answer signals is received within the second predetermined period. Inasmuch as both of the delay period T_d and the prescribed period T_p can be previously determined in the service area, the second predetermined period may be invariable despite the distance between the base stations and the automobiles.

Under these circumstances, the timing controller 42 supplies the timer 44 with a reset pulse RE during reception of each of the answer signals $RP_1, RP_2, \dots$, as shown in Fig. 3. The reset pulse RE disappears in synchronism with extinction of each answer signal. Supply of such a reset pulse RE is possible by monitoring the second predetermined period following each of the down paging signals.

Responsive to the reset pulse RE, the timer 44 is released to produce a gate pulse GP lasting during the first predetermined period T_a .

In the illustrated circuit arrangement, each time interval between two adjacent ones of the answer signals is determined

in advance so that it is not shorter than the first predetermined period T_a . In addition, the timing controller 42 monitors each of the answer signals. As a result, it may be said that the timing controller 42 serves to specify or define each time interval.

5 Thus, a combination of the timing controller 42 and the timer 43 is operable to define each time interval and to produce the gate pulse GP when each time interval is not shorter than the first predetermined period T_a .

10 Further referring to Fig. 2, the gate circuit 33 is supplied with the gate pulse GP to be opened during the presence of the gate pulse GP, namely, first predetermined period T_a which serves as unit time. As a result, the gate circuit 33 gates, during the first predetermined period T_a , the variable signal VR having a variable number of periods. The counter 34 counts the variable
15 number of periods during the first predetermined period to produce a count signal representative of a count. Responsive to the count signal and the reference signal supplied from the reference circuit 37, the comparator 36 produces an alarm signal AL representative of occurrence of jamming waves when the count exceeds the reference
20 value. The alarm signal AL is sent from the comparator 36 to the exchange unit 41.

As mentioned above, a combination of the counter 34, the comparator 36, and the reference circuit 37 serves to measure the intensity of electric field during the first predetermined
25 period T_a to detect occurrence of the jamming waves.

Thus, the circuit arrangement measures the intensity of electric field on production of each down paging signal to detect whether or not the jamming waves are present in the paging

channel. Timely or rapid procedure for restoration of the system is possible on occurrence of the jamming waves and enables the system to be prevented from any confusion resulting from a long-term interruption of the control channel.

5 An additional control signal may be transmitted from the base stations 11 through 13 to the automobiles 19 to forcibly stop each answer signal RP_1 , RP_2 , The additional control signal may be sent through either one of the paging and the access channels and serves to provide each time interval not shorter
10 than the first predetermined period T_a .

Referring to Fig. 4, a circuit arrangement according to a second embodiment of this invention is for use in combination with the circuit arrangement illustrated with reference to Figs. 2 and 3. In Fig. 4, the first base station 11 alone is depicted
15 merely for simplicity of illustration. The exchange 21 is represented by an exchange unit 41 and a first portion 31 both of which are similar to those illustrated in Fig. 2. It may be understood for the time being that the exchange unit 41 produces a detection signal DT in response to the alarm signal AL supplied from the
20 comparator 36 illustrated in Fig. 2.

As described with reference to Fig. 1, consideration is made of three of the speech channels S_1 , S_2 , and S_3 and the access channel A_1 in addition to the paging channel PC. Each
25 of the speech channels S_1 , S_2 , and S_3 comprises a down and an up speech channel for transmitting and receiving speech signals representative of speeches to and from the substations or automobiles, respectively.

As is the case with the system illustrated in Fig. 2, the first base station 11 comprises a paging channel transmitter 22, a paging channel receiver 23, a duplexer 26, and an antenna 27. The paging channel transmitter 22 is for transmitting the first and the second control signals AA and BB (suffixes omitted) to the automobiles 19 through the down paging channel. The paging channel receiver 23 is for receiving the answer signals RP from the automobiles through the up paging channel. For convenience of description, the paging channel transmitter and receiver 22 and 23 will be called a first transmitter and a first receiver hereinafter.

Furthermore, the first base station 11 comprises three of second transmitters 51, 52, and 53 for transmitting the speech signals to the automobiles through the down speech channels S_1 , S_2 , and S_3 , respectively, and three of second receivers 56, 57, and 58 for receiving the speech signals from the automobiles through the up speech channels designated by similar symbols S_1 , S_2 , and S_3 , respectively. Incidentally, a down access channel or third transmitter 61 and an up access channel or third receiver 62 are shown in Fig. 4. A transmitter multiplexer ~~synthesizer~~ 64 is interposed between the duplexer 26 and the respective transmitters 22, 51-53, and 61 while a distributor 65, between the duplexer 26 and the respective receivers 23, 56-58, and 62.

Now, the circuit arrangement comprises a first switching circuit 66 and a second switching circuit 67, both being responsive to the detection signal DT. The first switching circuit 66 is coupled to the first transmitter 22 and a selected one 53 of the second transmitters 51 through 53. Likewise, the second switching

5 circuit 67 is coupled to the first receiver 23 and a selected one 58 of the second receivers corresponding to the selected transmitter 53. In Fig 4, the selected transmitter 53 and the selected receiver 58 are operable in a selected one S_3 of the speech channels and are, therefore, related to each other in operation.

10 During absence of the detection signal DT, the first switching circuit 66 connects the first and the selected transmitters 22 and 53 to the exchange unit 41 through a paging channel output line 71 and a speech channel output line 72, respectively, while the second switching circuit 67 connects the first and the selected receivers 23 and 58 to the exchange unit 41 through a paging channel input line 73 and a speech channel input line 74, respectively. Responsive to the detection signal DT, the first switching circuit 66 is switched to connect the selected transmitter 53 to the exchange unit 41 through paging channel output line 71 with the first transmitter disconnected from the exchange unit 41, while the second switching circuit 67 is simultaneously switched to connect the selected receiver 58 to the exchange unit 41 through the paging channel input line 73 with the first receiver 23 disconnected from the exchange unit 41. As a result, the paging channel output line 71 and the paging channel input line 73 are connected to the selected transmitter 53 and receiver 58, respectively. The first transmitter 22 and the first receiver 23 are both isolated from the exchange unit 41.

30 Therefore, the first and the second control signals are transmitted from the selected transmitter 53 to the automobiles through the selected down speech channel S_3 . On the other hand, the answer signals are received by the selected receiver 58 through the selected up speech channel S_3 .

15 This shows that the selected _____

speech channel S_3 is used as a new paging channel.

Referring to Fig. 5, description will be made of operation of each automobile for use in combination with the land mobile telephone system illustrated with reference to Fig. 4. Inasmuch as the paging channel PC is switched to the third speech channel S_3 , as described in conjunction with Fig. 4, each automobile should search for the third speech channel S_3 newly used as a paging channel.

Accordingly, search operation for the third speech channel S_3 will be mainly described hereinafter. It is to be mentioned here that a paging channel, as a rule, broadcasts access channel (abbreviated to ACH) information which relates to an access channel and which is indicative of a directory number, namely, a code of the access channel.

The operation is started by carrying out usual procedure necessary in each automobile, as shown by a first stage SG_1 . The first stage SG_1 is followed by a second stage SG_2 in which the ACH information in the paging channel is monitored a prescribed period. If the ACH information lasts the prescribed period, the first stage SG_1 is carried out again after the second stage SG_2 . Otherwise, a third stage SG_3 follows the second stage SG_2 to search for a new paging channel, namely, third speech channel S_3 . The third stage SG_3 is carried out by scanning one of the channels. In order to search for the third speech channel S_3 , it is monitored whether or not ACH information is received during a period of, for example, 60 seconds through the channel in question, as shown by a fourth stage SG_4 . When the reception is unsuccessful, operation is returned back to the third stage SG_3 . Otherwise, the channel

scan is stopped to lock the channel in question, as shown by a fifth stage SG_5 . In this stage SG_5 , the number or code of the third speech channel S_3 is kept in each automobile as a new paging channel.

5 Thereafter, the third speech channel S_3 is used as the new paging channel in each automobile running within the first service zone 16 illustrated in Fig. 1.

10 With the system illustrated in Fig. 4, it is possible to avoid a trouble resulting from interruption of the paging channel, by shifting the paging channel to one of the speech channels. Therefore, any degradation of service is avoidable in the telephone control system.

15 While this invention has thus far been described in conjunction with a few embodiments thereof, it is readily possible for those skilled in the art to practice this invention in various manners. For example, the substations may not be automobiles but ships or fixed subscribers. The jamming waves may be monitored and measured in the access channel, instead of the paging channel. In Figs. 2 and 3, each time interval between two adjacent ones
20 of the answer signals may be directly monitored in each base station to measure the first predetermined period T_a .

CLAIMS

1. A circuit arrangement for use in a control station of a radio communication system comprising a plurality of substations each of which is communicable with said control station through radio channels comprising a control channel and a plurality of speech channels, said control channel comprising a down and an up control channel, said down control channel being for supplying said substations with a set of control signals produced in said control station and comprising first and second control signals among which said second control signals are for requesting said substations not to produce answer signals, said first control signals being for requesting selected ones of said substations to produce the answer signals with time intervals left between said answer signals, said up control channel being for successively transmitting the answer signals to said control station from said selected substations, the answer signals transmitted through said up control channel being subject to jamming waves of a variable intensity of electric field, said circuit arrangement comprising:

defining means for defining each time interval between two adjacent answer signals to produce a gate pulse lasting during a first predetermined period when said each time interval is not shorter than said first predetermined period; and

measuring means coupled to said defining means and said up control channel for measuring said intensity of electric field during said first predetermined period to detect occurrence of said jamming waves.



2. A circuit arrangement as claimed in Claim 1, at least one of said second control signals being arranged between two adjacent ones of said first control signals, each of the answer signals being to be received by said base station within a second predetermined period after extinction of each of said first control signals with said each time interval not shorter than said first predetermined period, wherein said defining means comprises:

timing control means for producing a sequence of timing pulses to define production of said first and said second control signals and reception of the answer signals and to provide said first predetermined period after said second predetermined period lapses; and

timer means responsive to said timing pulse for producing said gate pulse during said first predetermined period following said second predetermined period.

3. A circuit arrangement as claimed in Claims 1 or 2, wherein said measuring means comprises:

signal generating means coupled to said up control channel for generating a variable signal having periods variable with said intensity of electric field;

gate means coupled to said generating means and said timer means for gating the variable signal during the presence of said gate pulse;

counting means coupled to said gate means for counting a variable number of said periods in the variable signal received from said gate means to produce a count signal representative of a count of said counting means;





(Claim 3 continued)

reference means for producing a reference signal representative of a reference value; and

15 alarm producing means responsive to said count signal and said reference signal for producing an alarm signal representative of occurrence of said jamming waves when said count exceeds said reference value.

4. A circuit arrangement as claimed in Claim 1, said speech channels comprising down and up speech channels for transmitting and receiving speech signals representative of speeches to and from the substations, respectively, said circuit arrangement comprising
5 first transmitting means for transmitting said first and said second control signals to the substations through said down control channel, first receiving means for receiving the answer signals from the substations through said up control channel, a plurality of second transmitting means for transmitting the speech signals
10 to the substations through said down speech channels, and a plurality of second receiving means for receiving the speech signals from the substations through said up speech channels,

said circuit arrangement further comprising:

means coupled to said measuring means for producing
15 a detection signal when said jamming waves are measured by said measuring means;

first means responsive to said detection signal and coupled to said first transmitting means and a prescribed one of said second transmitting means for
20 selecting said prescribed one of said second transmitting means instead of said first transmitting means to transmit said first and said second control signals to the

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(Claim 4 continued)

substations through said prescribed one of said
second transmitting means; and

second means responsive to said detection
signal and coupled to said first receiving means and a
prescribed one of said second receiving means for
5 selecting said prescribed one of said second receiving
means instead of said first receiving means to receive
the answer signals from the substations through said
prescribed one of said second receiving means, said
10 prescribed one of said second transmitting means being
related in operation to said prescribed one of said
second receiving means.

5. A circuit arrangement substantially as
described herein with reference to Figs 2 and 3 or
15 Figs 4 and 5 of the accompanying drawings.



* C L M S *