

The invention relates to the field of radiogoniometry and more particularly to a radiogoniometric method suited to the processing of signals modulated in amplitude of the type A_{3J} or A₁ and a single channel radiogoniometer with a shift in the arrival time, to put this method into operation.

The measurement of the input angle of radioelectric emissions of the BLU without carrier amplitude modulation type, (type A_{3J} according to the international classification of this type of emission), or of the all or nothing amplitude modulation type (type A₁ according to this same classification), can not be obtained by means of a single channel radiogoniometer with a shift in the arrival time, of the conventional type. In general, the processing of this type of signal is therefore undertaken in a radiogoniometer having several receiving channels.

In fact, in the technique of radiogoniometry by interferometry, the value of the input angle α of a radioelectric wave is deduced from the dephasing between the signals received on two neighbouring antennae at a distance of d , measured by interferometry between two receiving channels. In a single channel radiogoniometer, for example of the type described in the American patent US-A-3 806 937, which only has one reception channel, the measurement of the input angle is carried out by a method of diverted interferometry by measuring the shift in the arrival time τ of the wave on the two antennae, $\tau = \frac{d}{c} \sin \alpha$, where c

is the speed of light. This measurement is possible for signals modulating a carrier, in amplitude or in frequency type A₃ or F₃, in the following manner: The outputs of the antennae are connected with variable delay lines,

and the outputs of these lines are connected with a hybrid quadrature coupler. The outputs of the coupler deliver combinations of the output signals of the antennae and a switch connects alternately, at a fixed rhythm,* the input of the receiver with one or other of the outputs of the coupler to create a signal which is modulated in amplitude. The modulated signal is significant, after detection, of the energy difference between the signals present at the outputs of the hybrid coupler. The switching period of the outputs of the coupler is selected so as to eliminate the influence of the modulation on the estimation of this energy difference such that it is only representative of the energy difference of the carriers. This switching frequency is therefore selected to eliminate up to the lowest frequencies of the spectrum of the natural modulation of the signal. The output signal of the detector is therefore solely a function of the shift in the arrival time on the two antennae and therefore the input angle α of the emission. This angle is sampled with respect to the normal at the interferometric measurement base, constituted by the two antennae, for an emission arriving with a zero elevation angle.

This signal is received in the receiver and is processed, after transposition, filtering and regulation, by a managing unit which delivers a servo signal to compensate by the delay lines the shift in the arrival time between the two antennae so as to obtain a zero phase shift between the inputs of the hybrid coupler; the regulating of the delay lines therefore gives a measurement of the input angle of the radio emission.

This solution is not applicable to the received signals modulated in a single lateral band, BLU, without a carrier, type A_{3J} , or modulated in amplitude by all or nothing, type A_1 , because the energy difference between the two outputs of the hybrid coupler is not only representative of the phase shift between the inputs of the coupler, but also translates the variations in the modulation signal. For example, in mode A_{3J} , the absence of energy at the carrier frequency means that the energy is representative of the modulation signal itself, and varies very differently depending on whether one is in a speech signal sequence of the 'period of silence', 'slightly voiced period' or 'very voiced period'. Likewise, in modulation of type A_1 , the messages emitted are binary word sequences which create the cutting of the amplitude of a carrier by all or nothing according to a digital rhythm; the energy of the signal may therefore be very variable from a period T to the following period.

The present invention has as an object a radiogoniometric method suited to process both the single lateral band signals without a carrier of the A_{3J} type, or the signals modulated by all or nothing, type A_1 .

According to the invention, a radiogoniometric method utilizing a single channel radiogoniometer with a shift in the arrival time, the goniometer comprising a measuring base formed by two antennae connected with the inputs of a hybrid quadrature coupler by the intermediary of controllable delay lines, a receiver, a control circuit for the delay lines, a managing circuit and a switch, the method comprising the following stages: the outputs of the coupler are alternately connected with the input of the receiver by the intermediary of the switch which

is controlled by a switching signal, the managing circuit generates the switching signal and processes a signal sampled in the receiver in order to produce a directional error signal as a function of the difference of the energy measured for the signal between successive switchings, and the control circuit for the delay lines is controlled by the said directional error signal, is characterized in that the managing circuit produces:

- a phase for the detection of the presence of the received signal during which the switch alternately connects the outputs of the coupler with the input of the reception channel in a fixed rhythm,
- a phase of analysis of the signal so detected in order to generate the said switching signal synchronized with the detected signal,
- and a phase for the validation of the energy measurements in order to confirm the continuity of the detected signal conditioning the generation of the directional error signal, and in that an analysis phase follows a positive validation phase, whereas a new detection phase follows a negative validation phase.

For a speech signal modulated in "A₃J", the analysis of the detected signal may be carried out for example by the method of acquisition of the melodic frequency described in French patent FR-A-2494017 by the applicant.

The invention also has as an object the single channel radiogoniometer with a shift in the arrival time, for undertaking this method.

The invention will be better understood, and other characteristics will become apparent with the aid of the following

description with reference to the attached figures.

- Figure 1 represents a synoptic diagram of the radiogoniometer according to the invention.

- Figure 2 is a synoptic diagram of the managing circuit represented in figure 1.

- Figure 3 is an example of a voiced signal at the start of speech.

- Figure 4 is a chronogram of the control signals in the managing circuit.

- Figure 5 is an example of a signal in the course of speech, with the clock switching signal for the measurement of the input angle on a single lateral band modulated signal.

- Figure 6 is an organigram indicating the principal stages of the processing method used in the device described above.

The radiogoniometric device according to the invention comprises means to synchronize the detection of the directional error voltage on the modulating signal and in particular, when the BLU signal is a speech signal, on the melodic frequency of the speech signal. The melodic frequency is the value of the frequency corresponding to the very marked temporal periodicity of the speech signal in the voiced segments. This melodic frequency, connected with the vibration of the vocal chords, varies from one individual to another and is comprised between 60 and 300 Hz. It is almost constant whatever the sound pronounced for the same individual, but the amplitude of the speech signal varies in a melodic period as a function of the sound pronounced.

Thus, the synchronisation of the detection of the directional error voltage on the melodic frequency makes this detection independent of the natural dynamics of the speech signal.

For this, the frequency of switching of the outputs of the hybrid coupler is selected so as to be equal to half the melodic frequency, each output of the coupler being connected with the reception channel during a melodic period. The directional error voltage calculated from the energy values measured in three successive half-periods of switching is only validated after confirmation of the stationary nature of the signal during these three half-periods.

The radiogoniometric device according to the invention therefore comprises means similar to those used in a radiogoniometer with a shift in the arrival time suited to the conventional reception of signals modulated in amplitude, associated with means for detection of the melodic frequency in the received speech signal, and with a particular managing circuit taking into account this melodic frequency in the case of a detection of a signal of type A_{3J} to control the switching of the outputs of the coupler and the measurement of the directional error signal.

Figure 1 represents a general diagram of all these means. The antennae A and B form the interferometric base. These are two identical antennae at a distance of d . The outputs of these antennae are connected with the inputs of two delay lines 10 and 11 having delay control inputs. The outputs of the delay lines 10 and 11 are connected with a hybrid quadrature coupler 20, the outputs of which deliver

combinations of the signals present at their inputs. If S_A and S_B are the signals of delayed antennae present at the output of the delay lines 10 and 11, and if S_C and S_D are the output signals of the hybrid quadrature coupler 20, these signals are written as follows:

$$S_C = \frac{1}{\sqrt{2}}(S_A + j S_B)$$

$$S_D = \frac{1}{\sqrt{2}}(S_B + j S_A).$$

Taking as phase reference the signal on the antenna A and assuming the two paths are paired in gain, the signals S_A and S_B are expressed as a function of the amplitude $S(t)$ and of the phase $\varphi(t)$ of the speech signal as follows:

$$\begin{aligned} S_A(t) &= S(t) e^{j(\omega_0 t + \varphi(t) + \omega_0 \tau_A)} \\ S_B(t) &= S(t) e^{j(\omega_0 t + \varphi(t) + \omega_0 \tau_B + \Delta\varphi)} \end{aligned}$$

in which ω_0 is the pulsation of the carrier signal, τ_A and τ_B are the delays introduced by the delay lines 10 and 11 respectively, and $\Delta\varphi$ is the phase shift at the output of the two antennae. For an emission arriving with an angle of elevation of zero, the phase shift, directly proportional to the shift in the arrival time, is likewise a function of $\sin \alpha$: $\Delta\varphi = 2 \pi \frac{d}{\lambda} \sin \alpha$, in which λ_0 is the wave-length of the carrier signal. The modules of the output signals of the coupler are therefore:

$$\begin{aligned} |S_C(t)| &= S(t) \sqrt{1 - \sin \Psi} \\ |S_D(t)| &= S(t) \sqrt{1 + \sin \Psi} \end{aligned}$$

where $\Psi = \Delta\varphi - \omega_0 (\tau_A - \tau_B)$.

The switching of the outputs of the coupler therefore creates a signal modulated in amplitude to the switching frequency, the modulation index of which depends on ψ . The radiogoniometer allows a characteristic error signal of this modulation to be produced, which may be cancelled by modifying the delays τ_A and τ_B introduced by the delay lines to compensate for the shift in the arrival time τ between the two antennae (and the phase shift $\Delta\varphi$).

For this, the outputs of the hybrid quadrature coupler are connected with the inputs of a switch 30 controlled by a switching clock H_C . The output of the switch is connected with the input of the receiver 40, the low frequency output BF of which is the reception signal. To determine the direction in which the emitter is situated, the measurement of the input angle of the emission is obtained by means of a managing circuit 50 having a first input connected with the output BF of the receiver and a second input connected with a regulated intermediate frequency input FI, sampling the intermediate frequency signal in the receiver.

In fact, the processing of the sampled signal to obtain the directional error voltage may be realized either on the low frequency demodulated signal, or on the regulated intermediate frequency signal. In the first case, it is necessary for the local oscillator of a mix used in the receiver to detect the modulated signal in a single lateral band to be perfectly tuned to the received frequency. In reality, this tuning is realized by a listening operator, and is never perfect. There is therefore a shunt of the local oscillator with respect to the received frequency. For the subsequent treatments of the signal with a view to the acquisition of the melodic frequency, it is necessary

for this shunt to always remain very much less than about ten Hertz. In the second case, i.e. by using the regulated intermediate frequency signal of the receiver, the necessary processing for the measurement of the melodic frequency is realized on the envelope of the single lateral band signal, this envelope presenting frequency characteristics similar to those of the speech signal itself. The radio-goniometer according to the invention allows one or other of the two treatments to be realized, as selected by the operator.

cy

The managing circuit 50 has an output connected with the switching control input H_C of the switch 30, and an output connected with the input of a control circuit 60, the outputs of which are connected with the control inputs of the delay lines 10 and 11 to cancel the shift in the arrival time between the signals transmitted by the antennae.

Figure 2 represents the detailed diagram of the managing circuit 50.

In this figure, the low frequency input BF of the managing circuit is connected with the input of an amplifier 51, the output of which supplies the amplified demodulated signal, $b(t)$. The output of this amplifier is connected with a first input of a switch 52 having a control input C_1 . The intermediate frequency input FI is connected to the input of an envelope detector 53, the output of which supplies a characteristic signal $a(t)$ of the envelope of the regulated intermediate frequency signal. This signal is applied to the input of an amplifier 54, the output of which is connected with the inputs of a switch 55,

on the one hand by a direct path, and on the other hand by a path comprising a capacity 56, which allows the centering of the signal detected on a selected mean component. The choice between the non-centred envelope signal $a(t)$ and the centred envelope signal $a'(t)$ is realized by a control applied to the input C_2 of the switch 55; the choice between the detected envelope signal (centred or not centred) and the low frequency signal $b(t)$ is realized as indicated above by means of the switch 52.

The signal to be processed is therefore present at the output of the switch 52. This output is connected with the input of a low pass filter of the Bessel type 57 of cut-off frequency equal to 1 KHz. The output of this filter is connected with the input of an analog-digital converter 58, the role of which is to sample the signal to be processed $a(t)$, $a'(t)$ or $b(t)$ at a sampling frequency F_E applied to the converter at the input of the clock H_E . The multiple output of this analog-digital converter is connected with the first input of a summing circuit 59, the multiple output of which is connected with the corresponding input of a buffer memory 61. The output of this buffer memory is connected on the one hand to the second multiple input of the summing circuit 59, and on the other hand to an input, termed the data input, of a control circuit 110. The converter 58 has a status output "STATUS" connected with a clock input for storage of the buffer memory 61, this memory also having an input for return to zero, CA_2 .

The operation of this unit is controlled by a calculator 100 comprising a processing unit MPU, 101, a random access memory RAM, 102, and a program memory PROM, 103, these means being connected together by a connecting bus 104.

This bus 104 also transmits the commands to the control circuit 110 which comprises an interface circuit PIA, 111, which receives interruption signals CA_1 or CB_1 and supplies the control signals C_1 , C_2 and CA_2 , a sequencer 112 which supplies in particular the sampling clock H_E to the analog-digital converter 58, and finally a sequencer 113 which delivers the switching clock signal H_C to the switch 30 connected with the outputs of the hybrid coupler 20 (see figure 1). The bus 104 is likewise connected with an output interface circuit PIA, 114, delivering the directional error signal to the control circuit 60 of the delay lines (figure 1). The managing circuit finally comprises a logic circuit 70 having an input connected with the output of the analog converter, giving the sign of the sample taken in the signal, $\overline{MSB}$, an input connected with a control output of the sequencer 112, and outputs connected with corresponding inputs of the interface circuit PIA, 111; the role of this circuit 70 is, in particular, the detection of the passages to zero of the speech signal for the measurement of the melodic period in mode A_{3j} and the detection of the interruptions of signal in mode A_1 . A detailed description of this circuit 70 and also a precise description of the control signals necessary for the managing circuit to function will be given hereinafter in the description of the functioning of the managing circuit, in connection with the chronogram of the control signals represented in figure 4.

As indicated above, the radiogoniometer according to the invention operates in mode A_{3j} based on the measurement of the melodic period. The process of acquisition of the melodic period used in this radiogoniometer may be that which is described in the French patent application

FR-A-2494017 in the name of the applicant. The method consists of detecting the melodic period in the speech from a reduced set of data measured on the received signal. This set of data is composed of measurements a_i of the energy in the successive alternations of this signal, and associated measurements t_i of the durations of these alternations. A test procedure is put into operation on this data for the measurement of the melodic period: an acquisition phase constituted by a first series of tests, when it is verified, gives an acquired character to the voicing and ends with the calculation of a first melodic period value, and a validation phase constituted by a second series of tests, when it is verified, confirms the acquired character of the voicing and ends with the actualisation of the value of the melodic period. According to the method described in the patent indicated above, the acquisition phase of the melodic frequency consists of detecting in the speech signal three groups of two successive alternations, the energy values of which $(a_{1p}, a_{1n}), (a_{2p}, a_{2n}), (a_{3p}, a_{3n})$ represented by vectors on the diagram of an example of a speech signal represented in figure 3, and the intervals of corresponding time between held alternations of the same sign, $(t_{12p}, t_{12n}), (t_{23p}, t_{23n})$, likewise indicated in figure 3, correspond to all the criteria indicated below:

$$1: a_{1p} > S_p; a_{1n} > S_n.$$

$$2: a_{2p} > \text{MAX}(\frac{3}{4} a_{1p}; S_p); a_{2n} > \text{MAX}(\frac{3}{4} a_{1n}; S_n);$$

$$|t_{12p} - t_{12n}| < t_{pn}; t_{12p} < T_M; \text{et } t_{12n} < T_M.$$

$$3: a_{3p} > \text{MAX}(\frac{13}{16} (a_{2p} + (a_{2p} - a_{1p}))); S_p)$$

$$a_{3n} > \text{MAX}(\frac{13}{16} (a_{2n} + (a_{2n} - a_{1n}))); S_n)$$

$$|t_{23p} - t_{23n}| < t_{pn}; t_{23p} < T_M; t_{23n} < T_M;$$

$$|t_{23p} - t_{12p}| < \Delta t;$$

$$t_{23n} - t_{12n} = \Delta t.$$

where S_p , S_n , t_{pn} , Δt and T_M are threshold values fixed by the processing.

In the radiogoniometer according to the invention, this acquisition phase of the melodic period is the same and is followed by a measurement phase of the directional error signal and of validation, which is, at the same time, a verification phase of the maintaining of the voiced character of the speech.

Figures 4,5 and 6 allow the functioning of the radiogoniometer according to the invention to be explained. Figure 4 represents the processed signal, i.e. firstly the centred envelope $a'(t)$ of an intermediate frequency signal modulated at A_{3J} by a speech signal, then, after the acquisition phase, the non-centred envelope signal $a(t)$. As indicated above, this envelope signal has frequency characteristics similar to those of the speech signal. In the diagram of figure 4, it is assumed that after a duration t_c following the measurement of the last energy value a_{3n} , the first measurement of the melodic period has been calculated by the processor. The organigram of figure 6 allows the different stages of the processing method used in the radiogoniometer according to the invention to be put in diagrammatic form; a first branch of this organigram corresponds to the processing carried out for a signal of type A_{3J} , whilst a second branch, having certain stages in common with the first, corresponds to the processing carried out for a signal of type A_1 .

In a first phase, termed the acquisition phase, the signal presence is detected and the characteristics of this signal are acquired. For this, the operator determines the mode of transmission. If the mode of transmission is A_{3J} , the operator chooses between a processing of the signal BF or a processing of the signal FI, by control of the switch 52 by C_1 . At BF it is always the signal $b(t)$ which is selected. At FI, in this first phase, it is the regulated intermediate frequency signal $a'(t)$ which is selected by control of the switch 55 by C_2 . With these selections being made, to obtain the first measurements, the processor controls the switching of the two outputs of the hybrid quadrature coupler at a fixed rhythm, namely for example at a switching frequency $F_c = 50$ Hz. The energy values

between passages to zero a_i are then calculated. This calculation is realized by adding the samples at the sampling frequency, namely 16kHz for example, taken on the signal between two passages to zero, these passages to zero being detected by the change of sign of the samples. As long as no measured energy is greater than the corresponding predetermined threshold S_p or S_n , no speech signal is considered to be present. When the energy in an alternation becomes greater than the corresponding threshold, the switch 30 of the outputs of the coupler is kept in the position which it had at the moment of exceeding, this being to avoid carrying out the acquisition of the melodic period at the output of the coupler where the energy is reduced by the combination of the phases in the coupler. The acquisition phase of the melodic period according to the method described in the patent referred to above, is therefore realized.

When the melodic period is acquired, i.e. a value of this period, $T = \frac{1}{2} (t_{23p} + t_{23n})$ has been calculated, the processor controls a second phase of processing, termed the analysis phase. When the processing takes place in BF, there is no change, but when this processing takes place in FI, the processor firstly controls the switching, through the input C_2 , of the switch 55 for the analysis of the signal $a(t)$, non-centred intermediate frequency envelope signal. Then, the processor controls the switching of the outputs of the hybrid quadrature coupler by a square signal H_C at a period double the melodic period, such that each output is taken into account during a duration T equal to the melodic period. This switching is carried out on three successive switching half-periods (see figure 4). In fact, a measurement of the shift signal is obtained from measurements of the energy values in three successive

melodic periods, two measured on one antenna and one measured on the other. The energy values in each melodic period, T_i , $i = 1, 2, 3$, are measured in FI by summation of all the signal samples taken in this period, and in BF by summation of the absolute values of all the samples taken in this period. The energies E_1 and E_3 are measured at the same output of the hybrid coupler, whilst E_2 is measured at the other output of the coupler. A directional error value E is then calculated from these three energy values: this directional error value is

$$E = \frac{1}{2} ((E_1 - E_2) + (E_3 - E_2)).$$

In the case of signals with a carrier, the acquisition of the directional error signal was carried out with respect to a reference which was the level of regulation of the carrier. On the contrary, the acquisition of the directional error signal is made here without a level reference. It is therefore necessary to normalise the calculated value E by relating it to the actual energy received, E_r , normalised by the maximum energy which can be received $E_{\max}$ over a switching period. The directional error signal S_E which will be transmitted to the control circuit of the delay lines will therefore be the function of the normalised value E' such that:

$$E' = E \cdot \frac{E_{\max}}{E_r}, \text{ where } E_r \text{ is given by:}$$

$$E_r = \frac{E_1 + E_3}{2} + E_2$$

A third phase, termed the validation phase, is then controlled by the processor. For this, a validation test is carried out on the energy values E_1 , E_2 , E_3 . The validation is

only obtained if $E_3 - E_1$ is less than a threshold value, e , and if E_1 and E_3 are greater than a threshold S . These conditions translate the continuity of the periodicity of the energy, i.e. the maintaining of the signal and the maintenance of its voiced character. The managing circuit provides the corresponding shift signal S_E to the control circuit 60 of the delay lines; this control allows the difference in energy between the two inputs of the hybrid coupler to be returned to zero, which difference, as indicated above, is directly connected to the shift in the arrival time. When the position of balance is obtained, $E = 0$ and the staggering between the two delay lines 10 and 11 cancels the shift in the arrival time $\tau = \frac{d \sin \alpha}{c}$. With this delay being directly linked to the input angle α of the emission, it is possible to read directly the direction of the radioelectrical emission.

When the validation test is negative, a switching is carried out, which is a function of the mode of transmission. This switching allows the test of validity to be carried out again on another group of three successive half-periods of switching, on the basis of the melodic period previously acquired, this being as long as a predetermined number N of half-periods has not been tested. If at the end of the analysis of this predetermined number N of half-periods none of the tests has been positive, the processor controls a new acquisition of the melodic period. If, on the other hand, in the course of this analysis a test of validity is positive, the directional error energy value E' is used to generate a shift signal S_E .

The signals permitting the control of the various means of the managing circuit described with reference to figure

2 to obtain the functioning described above in mode A_{3J} with reference to the organigram of figure 6, are represented in figure 5. The sequencer 112 delivers the sampling clock signal H_E to the analog-digital converter giving the values of samples on 8 bits. H_E may be constituted for example by pulses at the frequency 16 KHz. The binary output of the analog-digital converter is received at the summing stage 59; the addition is carried out on 12 bits for example between the output of the converter and the output of the buffer memory 61 used to store in the memory the result of the preceding addition. This method allows the sum of several successive samples to be prepared at the output of the converter between two interruptions characterized by pulses CA₁ at the corresponding input of the PIA 111. The buffer memory, constituted by rockers of type D, has a clock input connected, as indicated above, to the status output "status" of the converter; the status 1 of this signal indicates the periods during which the converter completes a conversion operation. A new value is therefore present on the descending front of this "status" output. The result of an addition is stored in the buffer memory 61 on the rising front of the signal HE. The summing circuit comprises three summing stages of 4 bits, these summing stages being wired to give the result of the addition in complement at 2 and the data issued from the analog converter being likewise given in complement at 2 on 8 bits. The value in complement at 2 on 12 bits at the input of the summing stage is obtained by wiring the 8 bits of the analog-digital converter on the 8 bits of low weight of the summing stages, the 4 bits of high weight of the summing stages all being connected to an output $\overline{\text{MSB}}$ giving the sign of the sample at the output of the converter. The result of the addition is thus obtained in complement at 2.

During the phase of acquisition of the melodic period the measurement of the energy $\bar{a}_i(a_{ip}$ or $a_{in})$ of the signal between two passages to zero, is obtained by adding the samples between two interruptions generated by the passages to zero of the signal as described in the patent application mentioned above. The logic circuit 70 (figure 2) is designed to allow this measurement of energy of the signal between passages to zero. The detection of the passage to zero is realized by comparing the sign of a sample with the sign of a preceding sample, by means of the output $\overline{MSB}$. For this, the signal $\overline{MSB}$ is stored in the memory by means of a first rocker 71, on the rising front of a positive pulse of a duration of 7 microseconds, appearing 11 microseconds after the descending front of the status signal "status" of the analog-digital converter. This control signal for storage on memory of the rocker 71 applied to the clock input CK_1 of this rocker is the signal O_2 represented in figure 5. The sign is liable to change after each conversion, i.e. on the descending fronts of the status signal "status". The signal $\overline{MSB}$ represented in figure 5 represents an example of change of status, a short pulse translating a false change of sign not having to be taken into account, whereas an actual change of sign is translated by a change of status of the output $\overline{MSB}$. For the comparison of the signs of two successive samples, the input and the output of the rocker 71 are connected to the two inputs of an exclusive OR gate 72, the output of which is itself connected to the input of a second rocker 73. This rocker generates pulses on changes of sign of the signal; for this, the clock input CK_2 of the rocker 73 is connected with the output of an inverter 74 receiving the status signal. The output Q_2 of the rocker 73 therefore passes to 1 after a change of sign, on the

rising front of the inverted status signal CK_2 , and returns to zero on the rising front of the pulses of the signal CK_1 . The signal at the output Q_2 is an interruption signal CA_1 applied to the interface circuit 111 which controls the reading of the buffer memory 61. This reading is followed by a return to zero of the buffer memory by a negative pulse provided by the output CA_2 of the PIA 111, of a duration of 1 microsecond, which follows the reading of the buffer memory. During this acquisition phase, the sequencer 112 permanently generates the pulses at the sampling frequency, H_E , and the sequencer 113 switches the outputs of the coupler at fixed frequency, namely 50 Hz as indicated above.

For the analysis phase , after the acquisition of the melodic period, the number N_E of samples to be added during a half-period of switching is a function on the one hand of the sampling clock frequency, and on the other hand of the switching frequency. This number is stored in the memory by the processor in a counter of the sequencer 112. In this phase, each descending front of the clock generates a conversion on the analog-digital converter and decrements the counter of the sequencer, the return to zero of this counter controlling the reading of the value of a measurement of energy E_i thus realized, and a new loading of the counter of the sequencer by the value N_E . This type of counting is realized during the entire phase of maintaining the voiced signal, for the measurement of the energies E_i and the calculation of the directional error signal S_E .

Taking into account the fact that the managing circuit may operate "under interruption", this system is likewise

suited to determining the direction of a radioelectrical emission in modulation of amplitude by all or nothing. In fact, the procedure may be similar, the comparison being made between the energy values collected at the two outputs of the quadrature coupler, switched, not at the melodic frequency, which would have no meaning in this type of transmission, but at a fixed rhythm, as long as no interruption of signal presence due to the modulation is detected.

The processing represented in the organigram of figure 6 is therefore carried out, in mode A_1 , by selecting in a first phase the signal $a(t)$ which is the detected envelope of the signal at intermediate frequency, not centred, received from the output FI of the receiver, by control of the switches 52 and 55, this signal being filtered by the Bessel filter 57. To detect the signal presence, the switching of the outputs of the coupler is controlled in this first phase at the frequency $F_C = 100$ Hz. For this, the energy on each path is calculated by adding the samples at the sampling frequency taken during a half-period of switching. As long as the energy over a half-period of switching remains less than a threshold, S' for example, the processor concludes from this that the signal is absent. As soon as it is in the presence of an energy greater than the threshold S' , the processor concludes therefrom the signal presence and controls the positioning of the switch 30 (figure 1) on the corresponding output of the hybrid coupler, awaiting a characteristic interruption signal of a transition of the signal. This interruption is supplied by a comparator 75 provided for this purpose in the logic circuit 70. For this, the output of the low pass filter is connected with the first input

of this comparator 75, the other input receiving a reference voltage V_0 . As soon as the amplitude of the signal is greater or less than V_0 , i.e. for all the transitions of the demodulated and filtered signal, the comparator is released. However, only the rising fronts are taken into account by the processor. The interruption signal present at the output of the comparator is applied to the input CBI of the PIA 111, this circuit being programmed to release a pulse on the rising front of CBI, which controls through the output H_C of the sequencer 113, the switching of the outputs of the hybrid coupler at a fixed rhythm, namely $F_C = 100$ Hz.

For the second phase, termed the analysis phase, the method is the same as that described above for a modulated signal in single lateral band without a carrier, i.e. three half-periods of switching are considered. The three corresponding energy values E_1 , E_2 , E_3 are measured alternately at the two outputs of the coupler and a characteristic directional error signal of the difference of the levels of the carriers at these two outputs is calculated.

In the third phase, the same test of validation as in the processing of a modulated signal of type A_{3J} allows the continuity of the signal to be verified. However, as soon as a test fails, the processor moves to await a characteristic rising interruption of the presence of the signal.

The invention is not limited to the form of embodiment described above with reference to the figures. In particular, the particular configuration of the circuits described may be modified, just as the logic control circuit

or the sampling frequency H_E applied to the analog-digital converter. In addition, in the above description, it was indicated that the shift signal was calculated from measurements of energy in three successive half-periods by difference of the half-sum of the first and third ($\frac{E_1 + E_3}{2}$) and

of the second E_2 . It would likewise be possible to modify the number of half-periods concerned by increasing it for example to 4 and by making the difference between the half-sum of the first and third measurements $\frac{E_1 + E_3}{2}$

and the half-sum of the second and fourth measurements $\frac{E_2 + E_4}{2}$.

The invention has been described as particularly applicable to the reception of signals of type A_{3J} or A_1 because these signals could not be processed in the previous systems. However, the radiogoniometry device according to the invention is capable of processing any type of signal modulated in amplitude (type A_3), by a speech signal according to the same method of processing, i.e. by measuring the energy values at the output of a coupler, switched at a rhythm double the melodic period, the error signal only being validated after verification of the continuity of the signal.

Claims

1. A radiogoniometric method utilizing a single channel radiogoniometer with a shift in the arrival time, the radiogoniometer comprising a measuring base formed by two antennae (A and B) connected with the inputs of a hybrid quadrature coupler (20) by the intermediary of controllable delay lines (10 and 11), a receiver (40), a control circuit for the delay lines (60), a managing circuit (50) and a switch (30), the method comprising the following stages: the outputs of the coupler are alternately connected with the input of the receiver (40) by the intermediary of the switch (30) which is controlled by a switching signal (Hc), the managing circuit (50) generates the switching signal and processes a signal sampled in the receiver in order to produce a directional error signal (Se) as a function of the difference of the energy measured for the signal between successive switchings, and the control circuit for the delay lines (60) is controlled by the said directional error signal, characterized in that the managing circuit (50) produces:

- a phase for the detection of the presence of the received signal during which the switch alternately connects the outputs of the coupler with the input of the reception channel in a fixed rhythm,
- a phase of analysis of the signal so detected in order to generate the said switching signal (Hc) synchronized with the detected signal,
- and a phase for the validation of the energy measurements in order to confirm the continuity of the detected signal conditioning the generation of the directional error signal, and in that an analysis phase follows a positive validation phase, whereas a new detection phase follows a negative



validation phase.

2. The radiogoniometric method as claimed in claim 1, characterized in that for a signal BLU with suppressed carrier modulated by a speech signal, the detection of the presence of the received signal results from the measurement performed on the signal sampled in the reception channel of a greater energy than a predetermined threshold with respect to a half period of switching at the fixed rhythm, and the measurement of a melodic period in this detected signal, and in that the rhythm of the switching control signal generated during the analysis phase is selected so as to be equal to double the preceding melodic period measured so that each combination signal at the output of the coupler is taken into account during a melodic period.

3. The radiogoniometric method as claimed in claim 2, characterized in that during an analysis phase, the managing circuit causes the measurement of energy values E_1 , E_2 and E_3 during three successive melodic periods, E_1 and E_3 being measured when the switch connects one of the outputs of the presence coupler with the input of the reception channel and E_2 being measured when the other output of the coupler is connected with this channel, the phase of validation being positive when the following validation test is verified:

- the energy difference $(E_3 - E_1)$ is less than a threshold e ;

- the energy values E_3 and E_1 are greater than a threshold S ;

and characterized in that the directional error signal is proportional to $((E_1 + E_3)/2) - E_2$.



4. The radiogoniometric method as claimed in claim 3, characterized in that the managing circuit again performs the same validation test up to a maximum predetermined number of melodic periods with the preceding rhythm measured in the case of the failure of a validation test, the validation phase being negative when the maximum number of periods has been tested, the validation phase being positive and the directional error signal being transmitted to the control circuit for the delay lines (60) as soon as a validation test is verified.

5. The radiogoniometric method as claimed in any one of the claims 2 through 4, characterized in that the recognition of a melodic period is established when the energy values in the three groups of two successive alternations of the sampled signal (a_{1p}, a_{1n}) , (a_{2p}, a_{2n}) , (a_{3p}, a_{3n}) and the corresponding time intervals between alternations of the same sign t_{12p} , t_{12n} , t_{23p} , t_{2n} correspond to the following criteria:

$$- a_{1p} > S_p ; a_{1n} > S_n ;$$

$$- a_{2p} > \text{MAX} \left(\frac{3}{4} a_{1p} ; S_p \right) ; a_{2n} > \text{MAX} \left(\frac{3}{4} a_{1n} ; S_n \right) ;$$

$$|t_{12p} - t_{12n}| < t_{pn} ; t_{12p} < T_M \text{ et } t_{12n} < T_M ;$$

$$- a_{3p} > \text{MAX} \left(\frac{13}{16} (a_{2p} + (a_{2p} - a_{1p})) ; S_p \right)$$

$$a_{3n} > \text{MAX} \left(\frac{13}{16} (a_{2n} + a_{1n}) ; S_n \right)$$

$$|t_{23p} - t_{23n}| < t_{pn} ; |t_{23p} - t_{12p}| < \Delta t ; |t_{23n} - t_{12n}| <$$



and $t_{23p} < T_M$ and $T_{23n} < T_M$,
 wherein S_p , S_n , t_{pn} , Δt and T_M are predetermined threshold
 values, the measurement of the melodic period then being
 $1/2 (t_{23p} + t_{23n})$.

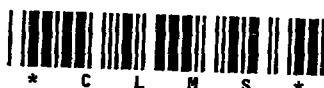
6. The radiogoniometric method as claimed in claim 1,
 characterized in that for a received signal modulated
 by a two level signal, the managing circuit (50) makes
 a decision on the presence of the received signal by comparing
 the level of the signal sampled at a predetermined level,
 V_0 , the switching signal generated during the phase of
 analysis having a fixed frequency and being interrupted
 at the time of interruption of the signal.

7. The radiogoniometric method as claimed in claim 6,
 characterized in that during a measurement phase the managing
 circuit causes the measurement of the energy of the sampled
 signal alternately so that for each output in three half
 periods of successive switching the measured amounts of
 energy are E_1 , E_2 and E_3 , E_1 and E_3 being measured when
 the switch (30) connects one of the outputs of the coupler
 with the input of the reception channel and E_2 being measured
 when the other output of the coupler is connected with
 this channel, the phase of validation being positive and
 negative respectively if the following validation test
 respectively is or is not verified:

- $(E_3 - E_1)$ less than a threshold e ;
- E_3 and E_1 greater than a threshold S ;

and characterized in that the directional error signal
 is proportional to $(E_1 + E_3)/2 - E_2$.

8. The radiogoniometric method as claimed in any one of
 the preceding claims, characterized in that the signal



sampled in the reception channel is selected as either the demodulated signal or the intermediate frequency signal, the processing means comprising a detector (53) for the intermediate frequency signal, amplification means (51 and 54), centering means (56) for the mean component for the intermediate frequency signal and a low pass filter (57).

9. A single channel radiogoniometer with a shift in the arrival time comprising a measurement base formed by two antennae (A and B) connected with the inputs of a hybrid quadrature coupler (20) by the intermediary of controllable delay lines (10 and 11), the outputs of the coupler being alternately connected with the input of a receiver (40) via a switch (30), and a managing circuit (50) generating a switch signal H_C applied to the switch and processing a signal sampled in the receiver in order to generate a directional error signal (SE) which is a function of the difference in the energy values measured, between successive switching operations, on the sampled signal, and a control circuit for the delay lines (60) controlled by the directional error signal, characterized in that the managing circuit comprises a demodulated signal input (BF) and an intermediate frequency signal input (FT) connected with the receiver, respectively connected with the inputs of a switch (52) via an amplifier (51) for the first one (BF), via a detector (53), an amplifier (54), and means for centering the continuous component (56) for the second one (FI), the output of the switch (52) being connected with a low pass filter (57) followed by processing means delivering the switching signal H_C synchronized with the detected signal, in the presence of a demodulated signal (BF).

