

Description

The present invention relates to radio navigation apparatus and methods, being more particularly concerned with navigation systems such as Loran-C which involve receiver selection of particular radio-frequency (RF) cycles to the pulses transmitted for positional determination.

Among the problems attendant upon present Loran-C radio navigation systems, are the difficulties associated with appropriate cycle selection at the receivers of the transmitted radio frequency (RF) pulses, and the high power required of the transmitting systems. Highly effective transmitters are described, for example, in U.S. Letters Patent Nos. 3,889,263, 3,786,334, and 3,711,725, and appropriate receivers for enabling reliable reception, for example, in U.S. Letters Patent Nos. 3,882,504 and 3,921,076.

A typical Loran-C pulse is a tear-shaped envelope of a plurality of successive radio-frequency cycles, more steeply rising than falling as shown in later-described Fig. 1A. Receivers operating with groups of such pulses select the third (RF) cycle of the pulse during their cycle selection process and then track the (RF) zero crossing of this third cycle as described in the above-mentioned receiver patents. This zero crossing is referred to as "The Standard Sampling Point", and the time-of-arrival of this zero crossing contains the precise timing information. Sometimes, however, the receiver may select the wrong cycle (the second or the fourth, for example), due to distortion in the leading edge of the envelope or slight misadjustment of the cycle-selection processing circuitry in the receiver. Such distortion in the pulse envelope may, for example, be caused by propagation anomalies; in particular, over land.

The parameter that determines how well the envelope is maintained relative to the ideal envelope is referred to as "The Envelope-to-Cycle Discrepancy," or "ECD". Most receivers have available a measure of ECD from envelope tracking circuitry; but, in general, it has been a troublesome parameter. The trouble arises when ECD becomes large and is interpreted by conventional receivers as incipient trouble. Some receivers react by reverting to the search mode in the hope of finding new signals; others interpret the problem as cycle slippage and jump a cycle; while others just light warning lights indicating incipient trouble.

In accordance with the present invention, such cycle ambiguity is admirably resolved, and with a reduction in required transmission power, by transmitting a coded group of RF pulses that provides unambiguous cycle selection using essentially the same signal format as presently used, for example in the Loran-C radio navigation system, and provides unambiguous position location with position repeatabilities of a few

feet and at ranges of several nautical miles. It is thus an object of the invention to provide such a new and improved radio navigation method and apparatus.

Other and further objects will be explained hereinafter and are delineated in the appended claims. By transmitting a waveform including a single navigation cycle that enables an unambiguous cycle selection, all the information necessary for navigation is maintained, the signal-to-noise ratio is unaffected, the cycle ambiguity problem is resolved at the receiver, and the required transmitter power is reduced by an order or magnitude.

One way of carrying out the invention is described in detail below with reference to drawings which illustrate only one specific embodiment in which:—

Figs. 1(A), (B), (C), and (D) are waveform graphs of a conventional Loran-C RF pulse, a desired single-cycle pulse, and its antenna currents and voltages;

Figs. 2(A) and (B) are similar waveforms of a preferred unambiguous navigation cycle pulse of the invention comprising a unique part of several half-cycles or parts thereof of a transmitted or radiated waveform, and the antenna current and voltage associated therewith;

Fig. 3 is a schematic circuit diagram of a preferred apparatus for carrying out the method underlying the invention;

Figs. 4(A) and (B) are waveforms illustrating the timing and operational voltages and currents generated in the apparatus of Fig. 3;

Fig. 5 is a schematic circuit of a transmitter apparatus with an additional network to improve the radiated spectrum; and

Fig. 6 shows waveforms illustrating the effect of the additional network for the spectrum improvement.

While providing the striking advantages of cycle-selection accuracy at the receiver and reduced power transmitter requirements, this new system does introduce certain difficulties (which are also overcome by the invention) which may explain the previous lack of obviousness of this approach to those skilled in this art. It is evident that the transmission of an electromagnetic field consisting of one single cycle of RF, as shown in Fig. 1(B), would achieve the objectives of this invention. However, there are certain practical problems associated with the generation of a radiated pulse having a field intensity in the form of a single cycle of RF. Since the waveform of the radiated electromagnetic fields (E and B fields) is equal to the time derivative of the antenna current, the antenna current waveform required to generate a radiated single cycle electromagnetic field must be of the form shown in Fig. 1(C). To generate an antenna current waveform of this type is not practical in the monopole type antennas used in hyperbolic navigation systems and which provide the desired uniform radiated field pattern. A monopole antenna is charac-

terized by a capacitance to ground which, together with the antenna tower inductance, radiation and ground resistances, forms a series resonant circuit. Thus, a unipolar antenna current of the form shown in Fig. 1(C) charges up the antenna capacitance so that a large amount of energy remains on the antenna at the termination time of the radiated pulse. The antenna voltage e_A resulting from this charge is shown in Fig. 1(D), and is impressed upon the output transformer of the transmitter, driving the transformer into saturation. When the output transformer saturates, it becomes a low impedance, causing the antenna capacitance to discharge and reverse polarity. This reverse antenna voltage, in turn, drives the output transformer into saturation in the opposite direction, causing the antenna capacitance to discharge and again reverse polarity. This action will repeat until all the antenna energy is dissipated in the radiation and loss resistances of the antenna system. For every antenna capacitance voltage reversal, a half-cycle of antenna current is generated. This causes spurious signals to be transmitted which are detrimental to the navigation function of the transmitting system. For this reason, the generation of the single-cycle field-intensity waveform shown in Fig. 1(B) is not practical when using monopole antennas.

This problem is overcome in this invention by transmitting an electromagnetic field having the waveform shown in Fig. 2(A). This waveform consists of several (four) half-cycles of alternating polarity. The first and fourth half-cycles have respective steep leading and trailing edges, being otherwise substantially sinusoidal, and are low in amplitude with respect to the intermediate complete second and third substantially sinusoidal half-cycles that together form a complete unique single cycle. The complete single cycle of interest is formed by the second and third half-cycles of the overall radio-frequency pulse waveform and provides a unique zero-crossing slope, being referred to herein for identification as the navigation cycle. The principal objective of this invention is to generate a propagating field that makes possible an unambiguous identification of the navigation cycle. It is evident from the waveform of Fig. 2(A) that such navigation cycle has the following unique characteristics:

1. The sum amplitude of the navigation (single) cycle is significantly greater than the sum amplitude of any other complete cycle formed out of this total waveform, such as first and second half-cycles, and third and fourth half-cycles.

2. The navigation cycle has opposite polarity to the other cycles; or equivalently, the zero-crossing slope at time t_2 in Fig. 2(A) is unique.

These two characteristics allow an unambiguous identification of the navigation cycle, the waveform of Fig. 2(A) providing the same advantages with regard to cycle selection as the

bare single-cycle waveform of Fig. 1(B) that is impractical for monopole antenna use as before explained, but may be useful in other applications as later explained.

To generate the radiated field intensity of the desired waveform of Fig. 2(A) from a monopole antenna, requires an antenna current waveform as shown in Fig. 2(B), with the resulting antenna voltage also there shown and so-labelled. Both the antenna voltage and current go to zero at the end of the pulse; that is, time t_4 in Figs. 2(A) and (B). Thus, no energy remains on the antenna at time t_4 , so that no spurious signals can be generated.

A schematic circuit diagram of a preferred embodiment of the transmitter power stage is shown in Fig. 3, and the voltage and current waveforms of this circuit are shown in Figs. 4(A) and (B). A D.C. power supply, so-labelled, is shown applying voltage E_s to a network comprising a first section containing a series-connected inductor L_1 and a solid-state switching relay or trigger-control device SCR1 or the like, and shunt capacitor C_1 . The next section of the network comprises a further switching device SCR2 series-connected to inductor L_2 and the primary winding of transformer T . The secondary winding of transformer T is connected to the antenna, schematically illustrated as series-connected inductance L_A , capacitance C_A and resistance R_A .

The operation of the circuit of Fig. 3 is as follows. Assume initially that capacitor C_1 is charged negatively to the value E_{C10} , Fig. 4(A). At time t_0 , SCR1 is turned ON and the charging of capacitor C_1 is initiated. During the charging interval of C_1 , t_0 to t_1 in Fig. 4(A), the voltage e_{C1} on capacitor C_1 is reversed; and at time t_1 , the charge current i_1 is reduced to zero and the voltage on capacitor C_1 has reached its maximum value E_{C11} .

In the time-interval t_1 to t_2 , this voltage on C_1 remains constant and provides adequate reverse recovery time for SCR1. At time t_2 , SCR2 is turned ON, and the energy on C_1 is transferred via the transformer T to the antenna capacitance C_A during the time interval t_2 to t_3 . The turns ratio 1:n of the transformer T is selected such that the capacitance C_1 is matched to the capacitance C_A so that all the energy on C_1 is resonantly transferred by current i_2 to C_A through transformer T and inductor L_A . Thus, during the time-interval t_2 to t_3 , the voltage on C_1 goes to zero, the voltage on C_A goes from zero to its maximum value, and a first half-cycle of radio-frequency antenna current i_A is generated, as shown in Fig. 4(B).

During the time-interval from t_2 to t_3 , the C_1 capacitor voltage is impressed across the primary winding of transformer T . This voltage drives the transformer core into saturation. At time t_3 , the transformer saturates and forms a low impedance path to the antenna circuit. Thus, the antenna capacitance C_A discharges

through $L_A R_A$ and the saturated transformer secondary inductance. Since this resonant circuit has a high Q , the voltage e_{CA} on C_A reverses to a negative value very close to its initial positive value, as also shown in Fig. 4(A). As a result, a second, this time negative, half-cycle of antenna current flows, Fig. 4(B), in the time-interval from t_2 to t_3 of magnitude very close to twice the antenna current magnitude of the first half-cycle of i_A . The circuit is tuned by means of inductors L_2 and L_A in combination with the saturated secondary transformer inductance such that the width, half period or time duration of the first two antenna circuit half-cycles is the same.

At time t_4 , the voltage on C_2 has reversed and the current i_A is reduced to zero. Thus, in the interval from t_4 to t_5 , the voltage e_{CA} drives the transformer T out of saturation and, since SCR_2 is still in a conductive state, the energy on C_A is transferred or fed back to C_1 through the inductors L_2 , L_A , the transformer T and SCR_2 . This energy transfer generates a positive third half-cycle of antenna current, Fig. 4(B), the magnitude of which is slightly less than the first half-cycle, but with the same time duration; this amplitude difference representing the energy dissipated in the radiation resistance of the antenna and circuit losses. At the end of the time-interval from t_4 to t_5 , the capacitor C_1 is charged to the negative voltage E_{C10} , the initially assumed voltage on C_1 . Thus, the circuit has restored the remaining energy and is ready for the generation of the next RF pulse. It should be noted that all the reactive energy has been recovered and is available for use in the generation of the next pulse. Thus, optimum circuit efficiency has been obtained, and only a relatively small amount of prime power is required. This is as distinguished from conventional Loran transmitters wherein all of the stored energy is dissipated in the antenna and antenna pulse forming networks (tailbiters). The antenna current waveform of Fig. 2(B), required for generation of the unambiguous navigation pulse of the invention, Fig. 2(A), is achieved. These pulses will be repetitively generated in successive time separation as is conventional in such Loran and related preselected time interval transmission operations. The unique navigation cycle RF pulses transmitted by the antenna $L_A-C_A-R_A$ are received in navigation receivers, so-labelled, provided with zero-crossing selecting circuits as described in the receiver patents above-referenced and the publications cited therein.

While useful in some applications, one disadvantage of the radiated field intensity wave shape of Fig. 2(A) is its wide spectral bandwidth that may cause serious interference with other radio navigation or communication systems. In particular, the discontinuities at the beginning and end of the radiated pulse generate high-frequency spectral components that can cause interference with other equip-

ment. Considerable improvement in the pulse spectrum can be obtained in accordance with the invention, and without degrading the navigational properties, by modifying the generation of the current pulse shape to that shown in solid line in Fig. 6; which has an oscillatory tail of substantially lower amplitude than the main navigational pulse. This pulse has no discontinuities in its waveform; and if an oscillatory tail is acceptable, only one slope discontinuity at the beginning of the pulse. Such a modified pulse can be generated by adding a shunt section to the circuit of Fig. 3. This new circuit is shown in Fig. 5, in which the added network consists of a shunt capacitor C_2 in parallel with a series interconnection of a switch S and resistor R_s . The switch S preferably consists of solid-state switching relays or devices such as SCR's or transistors. The operation of this circuit is as follows.

During the initial part of the pulse generation process, switch S is open, and capacitor C_2 , together with inductor L_2 , forms a filter that smooths out the antenna current slope discontinuity at the beginning of the pulse, as shown in Fig. 6. The dotted line in Fig. 6 is the waveform of the original current pulse generated by the circuit of Fig. 3, and the solid line is the waveform of the new improved antenna current pulse. The filter formed by L_2 and C_2 , however, will not eliminate the slope discontinuity at the end of the pulse. This slope discontinuity is eliminated by closing switch S some time during the time-interval of the third half-cycle of antenna current. During this time-interval, the energy stored in the antenna is transferred back to the transmitter circuit. Closing of the switch S during this time-interval interrupts this energy transfer, and the antenna energy dissipates instead in the resistor R_s . If the switch S is closed early in this time interval, all of the antenna transfer energy dissipates in the resistor R_s . If the switch S is closed late in this time-interval, only a small part of the transfer energy is dissipated in R_s ; thus, maintaining the high transmitter efficiency. When switch S is closed, capacitor C_2 rapidly discharges through R_s so that the reverse C_1 voltage appears across SCR_2 , thereby turning it OFF. The remaining energy in the antenna circuit generates an exponentially decaying oscillatory wave of antenna current, as shown by curve 2 in Fig. 6. By adjusting the resistor R_s such that the circuit formed by the elements C_2 , R_s , T , L_A , C_A , and R_A is critically damped, the antenna current decays exponentially to zero, as shown by curve 1 in Fig. 6. Minimum damping is obtained by reducing the resistor R_s to zero value. This condition results in the longest exponentially decaying oscillatory antenna current pulse tail, which, in turn, generates the least amount of harmonic energy.

While the invention has been described in connection with its preferred application to Loran C and similar navigation systems, its

advantages may also be used in other systems, if desired. If other types of antennas than monopole antennas or those of similar characteristics are to be used, there may indeed be useful application for the single or navigation cycle portion alone of the waveform of Fig. 2(A), in which event the first and fourth half-cycles would be adjusted by proper circuit parameters, as is well known, to be minimal or substantially zero.

Claims

1. A method in radio navigation and particularly Loran radio navigation comprising generating and transmitting a navigation pulse of radio frequency energy, receiving the pulse transmission and selecting a predetermined cycle in the waveform for timing information characterised in that the transmitted navigation pulse is composed of several half-cycles such as to include only one complete cycle of radio frequency energy which has a zero crossing slope in a direction unique to said waveform, the zero crossing of said one complete cycle being selected for timing information.

2. A method as claimed in claim 1 wherein the sum of the amplitudes of said one complete cycle is different from the sum of the amplitudes of any other cycle formed out of the other half-cycles of said waveform.

3. A method as claimed in claim 2 wherein the sum of the amplitudes of said complete cycle is greater than the sum of the amplitudes of said any other cycle.

4. A method as claimed in any preceding claim wherein said one complete cycle is generated by storing energy from a power source, transferring the energy to an antenna circuit to generate from part thereof a first half-cycle of radio frequency current, resonating the current in the antenna circuit to generate an opposite polarity second half-cycle of the radio-frequency current, and feeding back the energy remaining in the antenna circuit to the source to generate thereby a third half-cycle of radio-frequency current of the same polarity as the first half-cycle in the antenna circuit while restoring remaining energy for subsequent use.

5. A method as claimed in claim 4 wherein the path of said feedback energy is made resonant with the desired radio frequency in order to cause the second and third half-cycles to have the same time duration as the first half-cycle.

6. A method as claimed in claim 5 wherein the half-cycle amplitudes are adjusted such that the second half-cycle is of greater amplitude than the first and third half-cycles.

7. A method as claimed in any preceding claim wherein said generating and transmitting is repeated at pre-selected successive time intervals to generate groups of time-separated navigation pulses.

8. A method as claimed in claim 1 wherein

said transmitted radio-frequency navigation pulse comprises a first-half cycle of one polarity having a steep leading edge and a substantially sinusoidal trailing edge passing through zero into a second substantially sinusoidal, half-cycle of opposite polarity to said first half-cycle, and of greater amplitude, said second half-cycle returning through its zero crossing into a third half-cycle, of the said one polarity, which in turn returns through zero to a further half-cycle of said opposite polarity having a steep trailing edge returning to zero.

9. A method as claimed in claim 1 wherein said several half-cycle transmitted radio frequency navigation pulse comprises a first half-cycle of one polarity the trailing edge of which passes through zero into a second substantially sinusoidal, half-cycle of opposite polarity to said first half-cycle and of greater amplitude, said second half-cycle returning through its zero crossing into a third half-cycle of the said one polarity, which in turn returns through zero to a further half-cycle of said opposite polarity, terminating in a plurality of half-cycles of substantially lower amplitude than said four half-cycles.

10. A Loran radio navigation transmitter comprising energy storing means (C_1), antenna circuit means (L_A, C_A, R_A), means (L_2, T) interconnecting the energy storing and antenna circuit means, and switching means (SCR_1, SCR_2) for transferring energy from the storing means into the antenna circuit means, said switching means being controlled such that in operation the transmitter generates and transmits a navigation pulse in accordance with any one of claims 1 to 9.

Patentansprüche

1. Verfahren zur Funknavigation und insbes. Loran-Funknavigation, bei dem ein Navigationsimpuls von HF-Energie erzeugt und übertragen wird, die Impulsübertragung aufgenommen wird und ein vorbestimmter Zyklus in der Kurvenform zur Zeitsteuerung der Information ausgewählt wird, dadurch gekennzeichnet, daß der übertragene Navigationsimpuls aus mehreren Halbzyklen zusammengesetzt wird, derart, daß nur ein vollständiger Zyklus von HF-Energie enthalten ist, der eine Nullkreuzungsneigung in einer Richtung hat, die für die Kurvenform eindeutig ist, und daß die Nullkreuzung des einen vollständigen Zyklus zur Zeitsteuerung der Information ausgewählt wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Summe der Amplituden des einen vollständigen Zyklus unterschiedlich von der Summe der Amplituden eines anderen Zyklus gewählt wird, der aus den anderen Halbzyklen der Kurvenform gebildet wird.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die Summe der Amplituden des vollständigen Zyklus größer gewählt

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3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß die Summe der Amplituden des vollständigen Zyklus größer gewählt



wird als die Summe der Amplituden des anderen Zyklus.

4. Verfahren nach einem der vorausgehenden Ansprüche, dadurch gekennzeichnet, daß der eine vollständige Zyklus durch Speichern von Energie aus einer Energiequelle erzeugt wird, daß die Energie an eine Antennenschaltung übertragen wird, um aus einem Teil der Energie einen ersten Halbzyklus des HF-Stromes zu erzeugen, daß der Strom in der Antennenschaltung in Resonanz gebracht wird, um einen zweiten Halbzyklus entgegengesetzter Polarität des HF-Stromes zu erzeugen, und daß die in der Antennenschaltung verbleibende Energie in die Energiequelle rückgekoppelt wird, um dadurch einen dritten Halbzyklus des HF-Stromes gleicher Polarität wie für den ersten Halbzyklus in der Antennenschaltung zu erzeugen, während die verbleibende Energie zur nachfolgenden Verwendung wieder gespeichert wird.

5. Verfahren nach Anspruch 4, dadurch gekennzeichnet, daß der Pfad der Rückkopplungsenergie in Resonanz mit der gewünschten HF gebracht wird, um zu erreichen, daß die zweiten und dritten Halbzyklen die gleiche Zeitdauer wie der erste Halbzyklus haben.

6. Verfahren nach Anspruch 5, dadurch gekennzeichnet, daß die Amplituden des Halbzyklus so eingestellt werden, daß der zweite Halbzyklus eine größere Amplitude als der erste und der dritte Halbzyklus haben.

7. Verfahren nach einem der vorausgehenden Ansprüche, dadurch gekennzeichnet, daß die Erzeugung und Übertragung bei vorgewählten aufeinanderfolgenden Zeitintervallen wiederholt wird, um Gruppen von zeitgetrennten Navigationsimpulsen zu erzeugen.

8. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der übertragene HF-Navigationsimpuls einen ersten Halbzyklus einer Polarität mit einer steilen führenden Kante und eine im wesentlichen sinusförmigen ablaufenden Kante hat, die durch Null in einen zweiten, im wesentlichen sinusförmigen Halbzyklus entgegengesetzter Polarität zu der des ersten Halbzyklus übergeht und eine größere Amplitude hat, wobei der zweite Halbzyklus durch seine Nullkreuzung in den dritten Halbzyklus der einen Polarität zurückkehrt, der seinerseits durch Null hindurch in einen weiteren Halbzyklus der entgegengesetzten Polarität mit einer steilen ablaufenden, auf Null zurückkehrenden Kante zurückgeführt wird.

9. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß mehrere übertragene HF-Navigationsimpulse mit Halbzyklen einen ersten Halbzyklus einer Polarität aufweisen, dessen ablaufende Kante Null in einen zweiten, im wesentlichen sinusförmigen Halbzyklus entgegengesetzter Polarität zum ersten Halbzyklus und mit größerer Amplitude durchläuft, und daß der zweite Halbzyklus durch seine Nullkreuzung hindurch in einen dritten Halbzyklus der einen

Polarität zurückgeführt wird, der seinerseits durch einen weiteren Halbzyklus entgegengesetzter Polarität zurückgeführt wird und in einer Vielzahl von Halbzyklen mit wesentlich kleinerer Amplitude als die vier Halbzyklen endet.

10. Loran - HF - Navigationsüberträger mit einer Energiespeichervorrichtung (C_1), einer Antennenschaltung (L_A, C_A, R_A), einer Vorrichtung (L_2, T), die die Energiespeichervorrichtung und die Antennenschaltung miteinander verbindet, und einer Schaltvorrichtung (SCR_1, SCR_2) zur Übertragung von Energie aus der Speichervorrichtung in die Antennenschaltung, wobei die Schaltvorrichtung so gesteuert ist, daß im Betrieb der Überträger einen Navigationsimpuls nach einem der Ansprüche 1—9 erzeugt und überträgt.

Revendications

1. Procédé de radionavigation et, plus particulièrement, de radionavigation de type Loran, selon lequel on engendre et transmet un signal radioélectrique de navigation, puis on reçoit le signal transmis et on choisit une période déterminée dans le signal comme information de temps, caractérisé en ce que le signal de navigation transmis est constitué de plusieurs ondes de demi-période de manière à n'inclure qu'une seule onde de période complète du signal radioélectrique présentant une pente unique lors du passage par zéro du dit signal, le passage par zéro de la dite onde de période complète unique étant choisi pour constituer l'information de temps.

2. Procédé selon la revendication 1 caractérisé en ce que la somme des amplitudes de la dite onde de période complète unique est différente de la somme des amplitudes de toute autre onde constituée par les autres ondes de demi-période du dit signal.

3. Procédé selon la revendication 2 caractérisé en ce que la somme des amplitudes de la dite onde de période complète est supérieure à la somme des amplitudes de toute dite autre onde constituée par les autres ondes de demi-période du dit signal.

4. Procédé selon l'une quelconque des revendications précédentes caractérisé en ce que la dite onde de période complète est engendrée en stockant l'énergie d'une source d'alimentation, en transférant cette énergie à un circuit formant antenne de manière à générer à partir de celle-ci une première onde de demi-période d'un courant à fréquence radio, en mettant en résonance le courant dans le circuit formant antenne, de manière à engendrer une deuxième onde de demi-période de polarité opposée du courant à fréquence radio, et en envoyant l'énergie restante dans le circuit formant antenne vers la source, de manière à engendrer une troisième onde de demi-période d'un courant à fréquence radio de même polarité que la première onde de demi-période dans le



circuit formant antenne tandis que l'on restocke l'énergie restante pour un usage ultérieur.

5. Procédé selon la revendication 4 caractérisé en ce que le trajet de l'énergie renvoyée vers la source est rendu résonnant à la fréquence radio souhaitée, de manière à faire en sorte que les deuxième et troisième ondes de demi-période aient la même durée que la première onde de demi-période.

6. Procédé selon la revendication 5 caractérisé en ce que les amplitudes des ondes de demi-période sont ajustées de telle manière que la deuxième onde de demi-période présente une amplitude supérieure à celle des première et troisième ondes de demi-période.

7. Procédé selon l'une quelconque des revendications précédentes caractérisé en ce que les étapes de génération et de transmission sont répétées à des intervalles de temps successifs prédéterminés de manière à engendrer des groupes d'impulsions de navigation séparées dans le temps.

8. Procédé selon la revendication 1 caractérisé en ce que la dite impulsion de navigation transmise à fréquence radio comprend une première onde de demi-période d'une polarité présentant un front en prolongement de forme sensiblement sinusoïdale passant par zéro en devenant une deuxième onde de demi-période sensiblement sinusoïdale de polarité opposée à celle de la dite première onde de demi-période, et de plus grande amplitude, la dite deuxième onde de demi-période passant à son tour par zéro en devenant une troisième onde de demi-période, de la dite première polarité, qui, à son

tour, passe par zéro en devenant une autre onde de demi-période de la dite polarité opposée ayant un prolongement tendant vers zéro.

9. Procédé selon la revendication 1 caractérisé en ce que les dites impulsions de navigation transmises à fréquence radio et constituées de plusieurs ondes de demi-période comprennent une première onde de demi-période d'une première polarité dont le prolongement passe par zéro en devenant une deuxième onde de demi-période de forme sensiblement sinusoïdale et de polarité opposée à celle de la dite première onde de demi-période et d'amplitude supérieure, la dite deuxième onde de demi-période passant par zéro en devenant une troisième onde de demi-période de la dite première polarité, qui, à son tour, passe par zéro en devenant une autre onde de demi-période de la dite polarité opposée, se terminant par une pluralité d'ondes de demi-période d'amplitude substantiellement inférieure à celles des dites quatre ondes de demi-période.

10. Transmetteur pour système de radio-navigation de type Loran, comprenant un moyen de stockage d'énergie (C_1), un circuit formant antenne (L_A, C_A, R_A), un moyen pour relier le dit moyen de stockage et le dit circuit, et un moyen constituant un interrupteur (SCR_1, SCR_2) pour transférer l'énergie depuis le moyen de stockage jusqu'au circuit formant antenne, le dit moyen formant interrupteur étant commandé de telle manière qu'en fonctionnement, le transmetteur engendre et transmette une impulsion de navigation selon l'une quelconque des revendications 1 à 9.



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