CLAIMS

1. An apparatus (100) for rapid pain suppression, comprising:

- a main module (104), comprising data-storage means (110) and data-processing means (112);
- a synthesizer module (106); and
- one or more channel modules (108);

wherein:

* said data-storage means (110) contain data comprising:
  - first parameters (Vi), identifying a set of primitive waveforms (S00-S18), each primitive waveform (Si) having a periodic and predetermined time plot;
  - second parameters (T-packi, Freqi, T-sloti, T-Linki), which can be associated to each of said primitive waveforms (Si);
* said data-processing means (112) are designed and configured so as to process a set of data (Bi) identifying a sequence (S) made up of one or more of said primitive waveforms (Si) in temporal sequence, each of the primitive waveforms of the sequence (S) being processed on the basis of one or more of said second parameters (T-packi, Freqi, T-sloti, T-Link);
* said synthesizer module (106) comprises means for generating an electrical output signal (Out) corresponding to said sequence (S);

characterised in that said one or more channel modules (108) comprise means for application of said electrical output signal (Out) to a body using C fibres as primary vehicle for inducing analgesia, without blocking conduction of the C fibres, so as to excite the C fibres in order to convert the electrical stimulus into "non-pain" information in the C fibres themselves.

2. The apparatus (100) according to Claim 1, wherein said first parameters (Vi) comprise values of amplitude of each

primitive waveform (Si) of said set of primitive waveforms (S00-S18), wherein each of said primitive waveforms (Si) is represented in digital format by a corresponding vector (Vi) of values, expressed in the hexadecimal system:

V0 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 7F 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V1 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V2 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V3 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V4 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V5 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V6 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V7 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD

A5 9B 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V8 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY
C8 B6 A4 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50
60 70 78 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V9 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 04 08 0C 10 16
1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V10 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00
04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80
80 80 80 80 80 80 80 80 80

V11 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6
AD A5 9B 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50
60 70 78 80 80 80 80 80 80

V12 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC
BY C8 B6 A4 92 89 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40
49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80 80

V13 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 05 09 0E 18
1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80
80 80 80 80 80 80 80 80 80

V14 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00
05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F
80 80 80 80 80 80 80 80 80

V15 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6
AD A5 9B 92 80 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49
52 5B 64 6D 77 7F 80 80 80

V16 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V17 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V18 = 60 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80

3. The apparatus (100) according to Claims 1 or 2, wherein said data-storage means and data-processing means (110, 112) are designed to generate said set of data (Bi), in digital format, each datum (Bi) comprising at least:

- a first portion, identifying the primitive waveform (Si) selected to be repeated in succession in said sequence (S), to form a packet (Packi);
- a second portion, identifying a frequency value (Freqi) to be associated to said primitive waveform (Si) selected in the sequence (S); and
- a third portion, identifying a first value of temporal duration (T-sloti) to be associated to an interval of pause, subsequent to said packet (Packi).

4. The apparatus (100) according to Claim 3, wherein said data-storage means and data-processing means (110, 112) are designed to calculate moreover a second value of temporal duration (T-packi) to be associated to the duration of said packet (Packi).

5. The apparatus (100) according to any one of Claims 1 to 4, wherein said data-storage means and data-processing means (110, 112) are designed to select the waveforms (Si) with which to compose the sequence (S), on the basis of a

first criterion of a probabilistic type, said first probabilistic criterion involving the variable and dynamic selection of the waveforms (Si).

6. The apparatus (100) according to Claim 5, wherein said first probabilistic criterion is dynamically modified according to a first probabilistic filter based upon pre-set rules in such a way as to vary in a foreseeable and organized manner the probability of selection of each of said waveforms (Si).

7. The apparatus (100) according to any one of Claims 1 to 6, wherein said data-storage means and data-processing means (110, 112) are designed to calculate said second parameters (T-packi, Freqi, T-sloti, T-Link) for each waveform (Si) included in the sequence (S), on the basis of further probabilistic criteria, starting from pre-set values.

8. The apparatus (100) according to Claim 7, wherein said further probabilistic criteria for calculating said second parameters (T-packi, Freqi, T-sloti, T-Link) are dynamically modified according to respective further probabilistic filters based upon corresponding pre-set rules in such a way as to vary the probability of selection of said pre-set values.

9. The apparatus (100) according to any one of Claims 1 to 8, wherein said main module (104) processes each datum (Bi) of said set of data (Bi) in digital format, making it available as input for said synthesizer module (106), each datum (Bi) of said set of data (Bi) in digital format being preferably represented by a byte.

10. The apparatus (100) according to any one of Claims 1 to 9, wherein said data-storage means and data-processing means (110, 112), comprised in said main module (104) include a first programmable microprocessor, designed to process data on the basis of firmware stored in

corresponding storage devices.

11. The apparatus (100) according to any one of Claims 1 to 10, wherein said means for generating an electrical output signal (Out), comprised in said synthesizer module (106) include a second microprocessor (111), designed to read the data (Bi) supplied by said main module (104), and a first digital-to-analog converter (122), designed to convert the data received at input from said second microprocessor (111) into an analog signal (Out) corresponding to said sequence (S).

12. The apparatus (100) according to Claim 11, wherein said means for generating an electrical output signal (Out) further comprise a second digital-to-analog converter (120), designed to produce a modulating signal based upon pre-programmed data supplied by the second microprocessor (111) and used as reference for said first digital-to-analog converter (122), thus carrying out an amplitude modulation of the electrical output signal (Out).

13. The apparatus (100) according to any one of Claims 1 to 12, wherein said means for application of said electrical output signal (Out), comprised in each of said channel modules (108), comprise:

- a stage for filtering and amplification of the electrical signal (Out) issued by said synthesizer module (106);
- a stage for feedback regulation of the level of current of the output signal (Out);
- a safety electrical-decoupling stage; and
- devices for application of said regulated output signal (Out).

14. The apparatus (100) according to Claim 13, wherein each of said channel modules (108) further comprises a stage for amplitude modulation of the electrical output

signal (Out), said modulation being activated cyclically on just one of said one or more channel modules (108).

15. The apparatus (100) according to any one of Claims 1 to 14, wherein said one or more channel modules (108) are designed to perform the functions of filtering, modulation, and amplification of the output signal issued by the synthesizer module (106), feedback-regulation of the level of current of the output signal, necessary also for compensating variations of pressure on electrodes (160), effects of perspiration, alarm in the case of detachment or short-circuiting of the external wiring.

16. The apparatus (100) according to any one of Claims 1 to 14, further comprising at least one quartz synchronism generator (132), common to all the channels (108), designed to control the swing of a digital amplitude control (126), supplying a very precise temporal reference of the activity of the digital amplitude control (126).

17. The apparatus (100) according to Claim 16, wherein each channel module (108) comprises:

- at least one buffer (124);
- said digital amplitude control (126), connected to said buffer (124);
- at least one band-pass filter (128), connected to said digital amplitude control (126);
- at least one linear amplifier (130), connected to said band-pass filter (128);
- said synchronism generator (132), connected to said digital amplitude control (126);
- at least one comparator (134), connected to said digital amplitude control (126);
- at least one activation-window control (136), connected to said digital amplitude control (126);
- at least one low-pass filter (138), connected to said comparator (134) and to said activation-window

control (136);

- at least one sampling element (140), connected to said comparator (134);
- at least one precision rectifier (142), connected to said sampling element (140);
- at least one first separating transformer (144), connected to said precision rectifier (142);
- at least one second separating transformer (146), connected to said linear amplifier (130); and
- at least one protection and output-enabling element (148), connected to said first and second separating transformers (144, 146).

18. The apparatus (100) according to Claim 17, wherein said precision rectifier (142) is constituted by:

- at least one (+) peak detector (150-1);
- at least one (+) integrator (152-1), connected to the at least one (+) peak detector (150-1);
- at least one (-) peak detector (150-2);
- at least one (-) integrator (152-2), connected to the at least one (-) peak detector (150-2);
- at least one differential amplifier (154), connected to said (+) and (-) peak detectors (150-1, 150-2); and
- at least one buffer amplifier (156), connected to said differential amplifier (154).

19. A method for operating an apparatus according to Claim 17, wherein the signal generated by the synthesizer module (106) is collected at input and buffered (124) so that the parallelism of a number of channels does not generate problems of coupling, the digital amplitude control (126) performing three functions: 1) automatic regulation of the output as the load on the value set manually by the purposely designed potentiometric level control varies; 2) contribution to the amplitude sub-modulations not

otherwise managed digitally directly by the synthesizer module (106); 3) safety reactions with resetting of the output signal in the case of detection of functional anomalies.

20. The method according to Claim 19, wherein the temporal reference issued by the quartz synchronism generator (132) enables passage of the amplitude sub-modulations without interfering with the process of regulation of current that compensates the dynamic imbalances of the load or of the variations of the waveforms, said temporal reference, which is synchronized to the previous one, generated once again in the synchronization block, modulating periodically and slightly in amplitude the reference set manually of the intensity of the stimulus at output, thus obtaining one of the necessary sub-modulations that are not generated digitally in the synthesizer module (106).

21. The method according to Claim 19, wherein the determination of the direction in which to modify the amplitude of the signal as increment/decrement is made instantaneously in response to the feedback loop, which, together with the level set manually, constitutes the other input point of the comparator (134), this change of direction of the regulation being prepared, but not being activated until the consensus of the control of activation of the regulation is received, the control of activation analysing the oscillations of the comparator (134) and discriminating the useful part thereof, first through the low-pass filter (138), and subsequently with the window discriminator (136), wherein, when the signal resulting from this processing path identifies the effective need to regulate the deviation of the current measured with respect to the fixed one, the consensus for modification of the amplitude of the signal that is useful for compensating the difference found is generated, whereas,

when the process of analysis identifies a sub-modulation that must be made to pass, the consensus for the variation is denied.

22. The method according to Claim 19, wherein the signal processed is sent to the band-pass filter (128), which is designed to eliminate spurious modulations and complete the geometrical definition of the waveforms at output, whilst the linear power amplifier (130) drives the second separating output transformer (146) and, through a further system of protection (148), made up of varistors, limiting resistors, and relays, supplies the signal with the characteristics suitable for use.

23. The method according to Claim 19, wherein, from the output through the first separating transformer (144) a small portion of the signal is taken across a shunt resistor (143), said portion of signal being necessary for evaluating and regulating the effective current supplied and being converted into a d.c. voltage that can be used for said purpose.

24. The method according to Claim 23, wherein the precision rectifier (142) receives the signal duly insulated from the first galvanic-separation transformer (144) and carries out a filtering based upon just one integration system, which is calculated so as to allow the modulations to pass albeit maintaining the control of the average current supplied in the limits fixed manually, the single time constant, synergized with the other parameters of synchronism of the sampling, being exploited also for a particular amplitude modulation that is made at the start of each change of sequence for a short time of less than 300 ms.

25. The method according to Claim 23, wherein two different time constants are used, one for the negative half-wave and one for the positive half-wave, said half-

waves being integrated in a differential circuit before being sampled, this original circuitry introducing a specific nonlinear behaviour, said precision rectifier, together with the link sequence (T-linki), introducing at the start of each new packet an equal amplitude modulation that is effective and readily recognizable, and at the same time said circuit, maintaining the average current values set manually over a wide range of load impedances, without causing alterations of the modulations and of the geometries used for constructing the synthetic non-pain information, eliminating the troublesome sensation perceived by the patient in the step of regulation due to the temporary spurious stimulation of the A-Delta fibres.

26. The method according to Claim 24 or Claim 25, wherein the last processing of the feedback signal is performed always through a programmed sampling, the sampling envisaging stabilization of the response of the circuit, via further synchronization with the real-time synthesis of the waveforms generated at the moment by the synthesizer module (106).

27. A primitive waveform (Si) for generating an electrical signal to be used in a therapy for the suppression of a pain, said primitive waveform (Si) being represented by one of the following vectors of values of amplitude (V0...V18), expressed in the hexadecimal system:

V0 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 7F 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V1 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V2 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE

FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 20
40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V3 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD
A5 9B 92 80 00 20 40 60 6E 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V4 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY
C8 B6 A4 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V5 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 10 20 30 40 60
70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V6 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 10
20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V7 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD
A5 9B 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V8 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY
C8 B6 A4 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50
60 70 78 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V9 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 04 08 0C 10 16
1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80
80 80 80 80 80 80 80 80

V10 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE
FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00
04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80

80 80 80 80 80 80 80 80 80

V11 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80

V12 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 89 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V13 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V14 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80

V15 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80

V16 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V17 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V18 = 60 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80

28. A method for operating an apparatus according to Claim

1, said method comprising the following steps:

- supplying a set of primitive waveforms (S00-S18), each primitive waveform (Si) having a periodic and predetermined time plot, identified by first parameters (Vi);
- calculating second parameters (T-packi, Freqi, T-sloti, T-Link) that can be associated to each of said primitive waveforms (Si);
- processing a set of data (Bi) identifying a sequence (S) made up of one or more of said primitive waveforms (Si) in temporal sequence, each of the primitive waveforms of the sequence (S) being processed on the basis of one or more of said second parameters (T-packi, Freqi, T-sloti, T-Link); and
- generating an electrical output signal (Out) corresponding to said sequence (S).

29. The method according to Claim 28, wherein said first parameters (Vi) comprise values of amplitude of each primitive waveform (Si) of said set of primitive waveforms (S00-S18), each of said primitive waveforms (Si) being represented in digital format by a corresponding vector (Vi) of values, expressed in the hexadecimal system:

V0 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 7F 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V1 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V2 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V3 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V4 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V5 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V6 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V7 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V8 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V9 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V10 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80 80 80 80 80

V11 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6

AD A5 9B 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80

V12 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 89 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V13 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V14 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80

V15 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80

V16 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V17 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V18 = 60 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80

30. The method according to Claim 28 or 29, wherein each datum (Bi) of said set of data (Bi) is in digital format and comprises at least:

- a first portion, identifying the primitive waveform (Si)

selected to be repeated in succession in said sequence (S), to form a packet (Packi);

- a second portion, identifying a frequency value (Freqi) to be associated to said primitive waveform (Si) selected in the sequence (S); and

- a third portion, identifying a first value of temporal duration (T-sloti) to be associated to a pause interval, subsequent to said packet (Packi).

31. The method according to Claim 30, further comprising the step of calculating a second value of temporal duration (T-packi) to be associated to the duration of said packet (Packi).

32. The method according to any one of Claims 28 to 31, wherein the selection of the waveforms (Si) with which to compose the sequence (S) is executed on the basis of a first criterion of a probabilistic type.

33. The method according to Claim 32, wherein said first probabilistic criterion involves the variable and dynamic selection of the waveforms (Si).

34. The method according to Claim 32 or Claim 33, wherein said first probabilistic criterion is dynamically modified according to a first probabilistic filter based upon pre-set rules, in such a way as to vary in a foreseeable and organized manner the probability of selection of each of said waveforms (Si).

35. The method according to any one of Claims 28 to 34, wherein the calculation of said second parameters (T-packi, Freqi, T-sloti) for each waveform (Si) included in the sequence (S) is executed on the basis of further probabilistic criteria, starting from pre-set values.

36. The method according to Claim 35, wherein said further probabilistic criterion for calculating said second parameters (T-packi, Freqi, T-sloti) are dynamically modified according to respective further probabilistic

filters based upon corresponding pre-set rules in such a way as to vary the probability of selection of said pre-set values.

37. The method according to Claims 34 and 36, wherein said probabilistic filters are such as to minimize the probability of selection in succession of one and the same primitive waveform (Si), in association with one and the same parameter (Freqi) of said set of parameters (T-packi, Freqi, T-sloti).

38. The method according to any one of Claims 28 to 37, wherein said step of generating an output signal (Out) corresponding to said sequence (S) comprises a step of digital-to-analog conversion of said set of data (Bi) identifying the sequence (S).

39. The method according to Claim 38, further comprising the step of amplitude modulation of said output signal (Out).

CLAIMS

1. An apparatus (100) for rapid pain suppression, comprising:

- a main module (104), comprising data-storage means (110) and data-processing means (112);
- a synthesizer module (106); and
- one or more channel modules (108);

wherein:

* said data-storage means (110) contain data comprising:
  - first parameters (Vi), identifying a set of primitive waveforms (S00-S18), each primitive waveform (Si) having a periodic and predetermined time plot;
  - second parameters (T-packi, Freqi, T-sloti, T-Linki), which can be associated to each of said primitive waveforms (Si);

* said data-processing means (112) are designed and configured so as to process a set of data (Bi) identifying a sequence (S) made up of one or more of said primitive waveforms (Si) in temporal sequence, each of the primitive waveforms of the sequence (S) being processed on the basis of one or more of said second parameters (T-packi, Freqi, T-sloti, T-Link);

* said synthesizer module (106) comprises means for generating an electrical output signal (Out) corresponding to said sequence (S);

wherein said one or more channel modules (108) comprise means for application of said electrical output signal (Out) to a body using C fibres as primary vehicle for inducing analgesia, without blocking conduction of the C fibres, so as to excite the C fibres in order to convert the electrical stimulus into "non-pain" information in the C fibres themselves,

characterised in that said first parameters (Vi)

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comprise values of amplitude of each primitive waveform (Si) of said set of primitive waveforms (S00-S18), each of said primitive waveforms (Si) being represented in digital format DA a corresponding vector (Vi) of values, expressed in the hexadecimal system:

V0 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 7F 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V1 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V2 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V3 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 20 40 60 6E 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V4 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V5 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V6 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V7 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 10 20 30 40 60 70 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V8 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V9 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V10 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V11 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 04 08 0C 10 16 1C 22 28 2E 34 3A 40 50 60 70 78 80 80 80 80 80 80

V12 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 89 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V13 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V14 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 80 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80 80 80 80 80 80 80

V15 = 81 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE

FE FE FE FE FE FE FE FE FE FE FE F5 EC E3 BY D1 C8 BF B6 AD A5 9B 92 80 00 05 09 0E 18 1E 20 22 28 2E 34 3A 40 49 52 5B 64 6D 77 7F 80 80 80

V16 = B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE EC BY C8 B6 A4 92 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V17 = 81 B6 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FA EC DE D0 C2 B4 A6 9A 8E 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80

V18 = 60 AA D4 FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE FE F0 E2 D4 C6 B8 AA 9C 8E 81 00 11 23 34 3F 52 59 61 63 65 67 69 6B 70 75 7B 7D 80 80 80 80 80 80 80 80 80 80 80 80 80.

2. The apparatus (100) according to Claim 1, wherein said data-storage means and data-processing means (110, 112) are designed to generate said set of data (Bi), in digital format, each datum (Bi) comprising at least:

- a first portion, identifying the primitive waveform (Si) selected to be repeated in succession in said sequence (S), to form a packet (Packi);
- a second portion, identifying a frequency value (Freqi) to be associated to said primitive waveform (Si) selected in the sequence (S); and
- a third portion, identifying a first value of temporal duration (T-sloti) to be associated to an interval of pause, subsequent to said packet (Packi),

wherein said data-storage means and data-processing means (110, 112) are designed to calculate moreover a second value of temporal duration (T-packi) to be associated to the duration of said packet (Packi); and

wherein said data-storage means and data-processing means

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(110, 112) are designed to select the waveforms (Si) with which to compose the sequence (S), on the basis of a first criterion of a probabilistic type, said first probabilistic criterion involving the variable and dynamic selection of the waveforms (Si), said first probabilistic criterion being dynamically modified according to a first probabilistic filter based upon pre-set rules in such a way as to vary in a foreseeable and organized manner the probability of selection of each of said waveforms (Si).

3. The apparatus (100) according to Claim 1 or 2, wherein said data-storage means and data-processing means (110, 112) are designed to calculate said second parameters (T-packi, Freqi, T-sloti, T-Link) for each waveform (Si) included in the sequence (S), on the basis of further probabilistic criteria, starting from pre-set values, said further probabilistic criteria for calculating said second parameters (T-packi, Freqi, T-sloti, T-Link) being dynamically modified according to respective further probabilistic filters based upon corresponding pre-set rules in such a way as to vary the probability of selection of said pre-set values.

4. The apparatus (100) according to any one of Claims 1 to 3, wherein said data-storage means and data-processing means (110, 112), comprised in said main module (104) include a first programmable microprocessor, designed to process data on the basis of firmware stored in corresponding storage devices, and

wherein said means for generating an electrical output signal (Out), comprised in said synthesizer module (106) include a second microprocessor (111), designed to read the data (Bi) supplied DA said main module (104), and a first digital-to-analog converter (122), designed to convert the data received at input from said second

microprocessor (111) into an analog signal (Out) corresponding to said sequence (S), said means for generating an electrical output signal (Out) further comprising a second digital-to-analog converter (120), designed to produce a modulating signal based upon pre-programmed data supplied DA the second microprocessor (111) and used as reference for said first digital-to-analog converter (122), thus carrying out an amplitude modulation of the electrical output signal (Out).

5. The apparatus (100) according to any one of Claims 1 to 4, wherein said means for application of said electrical output signal (Out), comprised in each of said channel modules (108), comprise:

- a stage for filtering and amplification of the electrical signal (Out) issued DA said synthesizer module (106);
- a stage for feedback regulation of the level of current of the output signal (Out);
- a safety electrical-decoupling stage; and
- devices for application of said regulated output signal (Out);

wherein each of said channel modules (108) further comprises a stage for amplitude modulation of the electrical output signal (Out), said modulation being activated cyclically on just one of said one or more channel modules (108).

6. The apparatus (100) according to any one of Claims 1 to 5, further comprising at least one quartz synchronism generator (132), common to all the channels (108), designed to control the swing of a digital amplitude control (126), supplying a very precise temporal reference of the activity of the digital amplitude control (126), wherein each channel module (108) comprises:

- at least one buffer (124);
- said digital amplitude control (126), connected to said buffer (124);
- at least one band-pass filter (128), connected to said digital amplitude control (126);
- at least one linear amplifier (130), connected to said band-pass filter (128);
- said synchronism generator (132), connected to said digital amplitude control (126);
- at least one comparator (134), connected to said digital amplitude control (126);
- at least one activation-window control (136), connected to said digital amplitude control (126);
- at least one low-pass filter (138), connected to said comparator (134) and to said activation-window control (136);
- at least one sampling element (140), connected to said comparator (134);
- at least one precision rectifier (142), connected to said sampling element (140);
- at least one first separating transformer (144), connected to said precision rectifier (142);
- at least one second separating transformer (146), connected to said linear amplifier (130); and
- at least one protection and output-enabling element (148), connected to said first and second separating transformers (144, 146);

wherein said precision rectifier (142) is preferably composed of:

- at least one (+) peak detector (150-1);
- at least one (+) integrator (152-1), connected to the at least one (+) peak detector (150-1);
- at least one (-) peak detector (150-2);

- at least one (-) integrator (152-2), connected to the at least one (-) peak detector (150-2);
- at least one differential amplifier (154), connected to said (+) and (-) peak detectors (150-1, 150-2); and
- at least one buffer amplifier (156), connected to said differential amplifier (154).

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