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[Continued on next page]

(54) **Title**: ROULETTE WHEEL SYSTEM

(57) **Abstract**: A roulette wheel generates a first random number every game determined by the pocket into which a roulette ball falls. A second random number is generated every game from the motion of the ball, the wheel, or other factors.

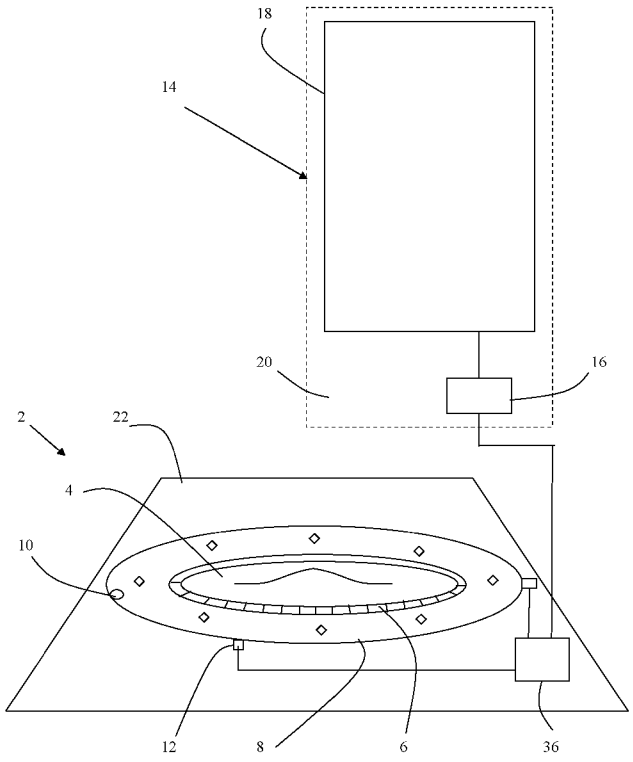

Fig. 1

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Roulette Wheel System

The present invention relates to a roulette wheel system, i.e. a system including a roulette wheel or adapted for use with a roulette wheel.

Background

Roulette is a well-known casino game which has been played for many years. A typical roulette wheel includes a number ring bearing a circular array of numbered segments bearing numbers 1 through 36. In addition, the number ring typically includes the numbers 0 and 00 disposed at diametrically opposite locations on the number ring, or a "0" on its own. The numbers 1 through 36 are not disposed in numerical order, but are typically disposed in a predetermined arrangement. The numbers disposed in a circular array in the number ring region of the wheel bear the alternating colours of red and black, with the exception of the 0 and 00 numbers, which are typically coloured green. A ring of pockets corresponding in number to the plurality of numbers of the circular number ring lies adjacent, but radially inward of the number ring, on the typical roulette wheel. In addition, a typical roulette wheel includes a circular, inclined ball track, disposed above, and radially outwardly of the number ring.

In operation of a typical roulette game, players place chips or tokens on a betting layout located on a roulette table, and then the croupier or dealer spins the roulette wheel to place the ball in motion about the circular ball track. As the wheel slows, the ball moves radially inwardly and comes to rest in one of the pockets associated with a particular number of the number ring. After the ball comes to rest in one of the pockets, the croupier or dealer settles the various wagers placed on the table layout in accordance with predetermined rules and wager odds and the process is repeated.

A computer-controlled display may be provided to display information about the game, including for example the winning number and previous winning numbers.

In EP 2 298 422 a way of generating two random numbers from the play of a roulette game is described. By generating a second random number a variety of additional bets and gambling opportunities can be generated.

By generating the second random number from the same game that generates the first random number, the generation of the second random number does not add to the time taken to play each game. The second random number is not generated purely electronically, which increases the confidence of players and may in any event be required by gaming authorities.

By generating the second random number from the motion of the single ball and the roulette wheel, possibly with additional information, the generation of the first conventional random number is not affected in any way allowing those players who wish to play purely conventional roulette to do so.

There may be a need to generate multiple random numbers from the motion of a roulette wheel. However, it is important to generate independent random numbers. If the random numbers are correlated, this may give rise to opportunities for players to combine bets in a way that gives them an expectation of winning, to the disadvantage of the Casino operator.

There is therefore a need for a way of generating multiple independent random numbers from the motion of a roulette ball.

Summary of Invention

According to the invention, there is provided a roulette wheel system for a game of roulette in which for each game of roulette a ball is introduced to a rotating roulette wheel and settles in a pocket, the game of roulette passing through predetermined states. The system includes at least one sensor for measuring a plurality of values, each value being a physical measurement of the position of the roulette wheel or the ball at a predetermined state, a physical measurement of the velocity of the roulette wheel or the ball at a predetermined

state, the time of a predetermined game state or the length of time between predetermined states. At least one processor is arranged to detect a plurality of states and to generate as a first random number the number of the pocket into which the ball falls; and arranged to generate a plurality of further random numbers from the measured values. Each further random number is generated from a respective set of the values, wherein each set of values includes at least one uncorrelated value that is uncorrelated with at least one value in any of the other sets of values so that the random numbers are independent random numbers.

One way of providing uncorrelated values is to include a timer for determining times to a resolution of better than 10 ms, wherein the uncorrelated values of the plurality of sets include different lengths of times of a predetermined state or states.

In some cases, the uncorrelated value of at least one set may be the starting time of one of the states.

The timer may be adapted to measure time in units, each unit being in the range 0.1ms to 10 ms, and the random numbers may be generated from the least significant digits of the measured times.

The plurality of sensors may include a camera recording the rotational position of the ball and/or the wheel, in which case the uncorrelated sensor information items of at least some of the plurality of sets may include different positions and/or velocities of the ball or wheel in a predetermined state or states.

Any value that is not evenly distributed may be included in a set of values with at least one other value. In this way, the uneven distribution of one value does not cause uneven distribution of the output.

Note in this regard that it is possible for the value that is not evenly distributed to nevertheless be uncorrelated. Thus, by combining values to produce

random numbers in this way a greater number of independent, uncorrelated and yet uniformly distributed random numbers may be distributed.

Brief Description of the Drawing

Preferred embodiments of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows a first embodiment of the invention;

Figure 2 is a flow diagram illustrating the operation of the first embodiment of the invention.

The drawings are schematic and not to scale. Like or corresponding features may be given the same reference numbers in the different figures, and the description is not necessarily repeated.

Detailed Description of Embodiments of the Invention

A roulette wheel 2 has a rotor 4 with pockets 6 on the periphery of the rotor. In accordance with convention, the pockets are numbered from 1 to 36 and with either a single 0 or a 0 and a 00 depending on local law and practice. The pockets numbered 1 to 36 are also traditionally coloured red and black. An integral roulette wheel controller 36 is also provided.

An inclined ball track 8 surrounds the rotor 4.

To play a game, the rotor 4 is rotated and a single ball 10 is introduced into the ball track 8 (step 100). Eventually, the ball 10 falls into a pocket which generates a random number 0, 00, or a number from 1 to 36 (Step 102). This number will be referred to as the first random number in this description.

In the first embodiment, sensors 12 are provided to detect the ball, one on the rim to detect the ball in the ball track and at least one to detect which pocket

the ball has arrived at. These sensors are connected to a display apparatus 14, which may also be termed a billboard. The display apparatus 14 includes a computer 16 and a display screen 18. Further sensors 12 detect the speed of the rotor.

The introduction of the ball 10 into the ball track 8 and the rotation of the rotor 4 may optionally be mechanised as is known in the art - these details will accordingly not be discussed further. Further conventional features of the roulette wheel such as a cover, ball interrupters to disrupt the flow of the ball and the like may also be included if required.

The roulette wheel sensors 12 detect (step 104) a number of pieces of information which are sent to the display apparatus 14. These pieces of information include the winning number, i.e. the number of the pocket into which the ball falls for each game, the first random number. Further information is also provided, including in particular the position of the roulette wheel. Many of the random numbers are determined from the position of the wheel at particular states of play of the game.

One of the sensors is a system clock or timer which can determine times to a high accuracy, preferably better than 10 ms, and typically in the range 0.05 ms (i.e 50 ns) to 10 ms. In the embodiment, the timer clocks at 125ns. The system clock is a 32-bit counter, which counts at a rate of one tick per millisecond.

The states of the game in particular include the "Place Bets" state, which occurs at the start of the game, a "No more Bets" state after which no more bets can be placed, and a "Winning Number" state which starts when the system identifies which pocket the ball has fallen. These states are determined automatically by the system.

In a first embodiment, the processor 36, which acts as a roulette wheel controller/processor takes the information from sensors 12 and creates random numbers as follows.

One of the random numbers is simply the random number indicated as in the normal game of roulette by the pocket the ball comes to rest in. The random number is accordingly in the range of 0 to 36 with the possibility of a "00" output where required or allowed by the gaming authorities of some countries.

Each of the further random numbers is generated from a different source from the current game in play. Each further random number is an eight-bit value with a range of 0-255 unless otherwise stated. Each further random number is generated from a set of two values.

The difficulty is to ensure that the further random numbers are not correlated with each other or with the normal random number.

The first further random number is available from the start of the game state "Place Bets." The number is derived from the system clock time and the rotor position at the start of this state. The rotor position is measured as an offset from the start of the last inner zebra strip edge seen. The system clock is measured at the start of the game state "Place bets".
The first further random number is generated from the exclusive OR'ed combination of the lower 8 bits of the rotor position and system clock.

The second further random number is available from the start of the game state "Place Bets." The number is derived from the ball position and the rotor position at the start of this state. The Ball position is measured using a separate 32 bit free running clock from the system clock, also ticking at 1ms from an independent timing source. The rotor position is measured as an offset from the start of the last inner zebra strip edge seen.
The second further random number is generated from the exclusive OR'ed combination of the lower 8 bits of the rotor position and ball position.

The third further random number is available from the start of the next game state, "No More Bets.". The number is derived from the length of the game state "Place bets" and the rotor position at the start of the game state "No more bets". The system clock is used to measure the length of game state "Place bets", i.e. the time between the start of the game state "Place bets" and the start of the game state "No more bets".
The third further random number is generated from the exclusive OR'ed combination of the lower 8 bits of both values is used to generate this random bonus number.

The fourth random number is available from the start of the game state "Winning Number." The number is derived from the total length of the game states "Place Bets" and "No more bets" and the position of the rotor at the start of game state "Winning Number". The system clock is used to measure the total length of game states "Place Bets" and "No more bets", i.e. the time between the start of the game state "Place bets" and the start of the game state "Winning Number".
The fourth further random number is generated from the exclusive OR'ed combination of the lower 8 bits of both values.

The fifth further random number is available from the start of the game state "Winning Number." In this case, the time of the system clock at the start of the state "Winning Number" is used together with the rotor position at the start of the game state "Winning Number".
The fifth further random number is generated from the exclusive OR'ed combination of the lower 8 bits of both values.

Note that the times and lengths of times used are uncorrelated with teach other, at least in the least significant digits used. This is because there are sufficient cycles of the lower 8 bits of the system clock (one cycle takes 256 ms) between the "Place bets" time and the "Winning number" time that the least significant bits of these times are uncorrelated.

Additional random numbers may optionally also be available.

A sixth further random number is available from the start of the game state "Place Bets". The number is derived from the system clock and the rotor position at the start of the game state "Place Bets". The rotor position is measured as an offset from the start of the last outer zebra strip edge seen before the start of the "Place bets" state.

To obtain the sixth random number, the exclusive OR'ed combination of the lower 16 bits of the clock value and the 16 bits of the position are used.

Alternative further random numbers may be produced in the same way.

The above embodiment uses the system clock as a timer to high accuracy and that can therefore be used to decorrelate random numbers. The system clock information is combined with a further measured value to further reduce the chance of any correlations.

Thus, each set of values used to generate corresponding random numbers includes one timing value - either the time at the start of a state or the length of time of one or more states - and a position value. These two are combined to generate the random numbers. Importantly, the timing values of each set are uncorrelated from the timing values of every other set to ensure that the generated random numbers are uncorrelated.

All the generated random numbers may be displayed on the display 14.

The invention may use any suitable roulette wheel, either manual or automatic.

Note that although the described embodiment includes first processor 36 and or second processor 30, the computer 16 includes a processor which may be used to carry out all of the processing by providing suitable software.

The embodiment described above assumes that accurate timings are available from a system clock and sensors. However, such information is not always available. An alternative approach for monitoring roulette wheels is to use a camera.

Accordingly, a second embodiment uses a digital video camera focussed on the roulette wheel to view position of the wheel and ball over time. The captured video may be analysed to extract timing information and position information from which to generate random numbers. In this case however the camera may typically only operate at 30 frames per second so that the timings are only accurate to 1/30 s. This means that the number of digits of accuracy is less so different approaches are required to ensure decorrelation between generated random numbers. In this case, therefore, the timing values alone are not enough to function as uncorrelated values to ensure decorrelation.

For this reason, in this embodiment position information is used to a greater extent - the position of the ball and the rotor can both be measured to relatively high accuracy using video cameras - to generate around 300 distinct rotor positions and ball positions around the wheel. For example, each of these positions may be represented by a number between 0 and 255.

The time for each game state cannot normally be used on its own since each game state does not last long enough when measured at a resolution of 1/30 s to generate an evenly distributed number from 0 to 255.

Wheel speed may be calculated as position values per second. Typical wheel speeds in a game vary from 15-25rpm which over 1 second gives a likely spread of about 50 independent values of speed.

Ball position is measured whenever the ball is in the ball track. The 360 degrees of the wheel is split into 256 parts, so in principle, the ball position at various game stages could generate one random number.

The random number generation system below aims to ensure that each bonus number has a uniform distribution in the range 0-255 and also that it is independent of any other bonus numbers in this or another game.

In this case, the set of values used to determine the first further random number is simply a single value, the length of time at the start of the "Place Bets" state from the "Place bets" state of the previous game. This time is measured modulo 256, i.e. the last 8 bits of the binary representation of the time is used. Since the time of a game is long compared with 256 frames, i.e. long compared with 8.5s, a uniform distribution is expected. For the first game, the time since system start up is used.

The second set of values, used to determine the second further random number, is taken from position information 1 second after the start of the "Place bets" state. The 1 second delay allows the wheel and ball speed to settle and become accurately measurable. The values are the rotational position of the wheel (0 to 255) and the rotational position of the ball (0 to 255).

The third set of values, used to determine the third further random number, is taken from position information at the start of the "No further bets" state. The "No further bets" state starts when the ball speed falls below a predetermined value. The values are the rotational position of the wheel (0 to 255) and the rotational position of the ball (0 to 255).

The fourth set of values, used to determine the fourth further random number, is taken from position information at the start of the "Winning Number" state. The values are the rotational position of the wheel (0 to 255) and the time interval from the start of the "Place Bets" state to the "Winning number" state. The time interval is too short for itself to be entirely evenly distibuted - the reason for its use is discussed below.

The fifth set of values, used to determine the fifth further random number, is taken from the last ball position at the start of the "Winning Number" state,

multiplied by 4, plus the total number of revolutions the ball has performed since the start of the game.

It might be wondered why two values are used, for example in the fourth set of values, where one of the values is not evenly distributed. The reason for using two values is that the least significant bit of position information may not be completely evenly distributed either. The rotor position is reported using an accuracy of 0 to 255, but the measurement is made using a discrete calculation from a discrete (pixelised) image which may, for example report a value in the range 0 to a different number, for example of order 1000. Therefore, when the rotor position is converted to a number 0 to 255, some values may occur more frequently than others, since each input value can only be converted to a single output value in the range 0 to 255 so unless the original measurement is an integral multiple of 256 some values in the range 0 to 255 will correspond to more original measurements than others, so the frequency of each value may not be identical.

This degree of uneven distribution can be compensated for by using another value which can spread the unevenness and hence result in a true random output.

Note that the sets of values used in both the above embodiments can include one, two or three values. In principle, more may be used but above three values there is not normally any gain in randomness and of course more values requires more calculation.

CLAIMS

1. A roulette wheel system for a game of roulette in which for each game of roulette a ball is introduced to a rotating roulette wheel and settles in a pocket, the game of roulette passing through predetermined states, the roulette wheel system comprising:

at least one sensor for measuring a plurality of values, each value being a physical measurement of the position of the roulette wheel or the ball at a predetermined state, a physical measurement of the velocity of the roulette wheel or the ball at a predetermined state, the time of a predetermined game state or the length of time between predetermined states;

at least one processor (16,30,36) arranged to detect a plurality of states and to generate as a first random number the number of the pocket into which the ball falls; and

arranged to generate a plurality of further random numbers from the measured values;

characterised in that each further random number is generated from a respective set of the said values, wherein each set of values includes at least one uncorrelated value that is uncorrelated with at least one value in any of the other sets of values so that the random numbers are independent random numbers.

2. A roulette wheel system according to claim 1, wherein the roulette wheel system includes a timer for determining times to a resolution of better than 10 ms, wherein the uncorrelated values of the plurality of sets include different lengths of times of a predetermined state or states.

3. A roulette wheel system according to claim 2, wherein the uncorrelated value of at least one set is the starting time of one of the states.

4. A roulette wheel system according to claim 2 wherein the timer is adapted to measure time in units, each unit being in the range 0.1ms to 10 ms,

and wherein the random numbers are generated from the least significant digits of the measured times.

5. A roulette wheel system according to claim 1, wherein the plurality of sensors includes a camera recording the rotational position of the ball and/or the wheel, wherein the uncorrelated sensor information items of at least some of the plurality of sets include different positions and/or velocities of the ball or wheel in a predetermined state or states.

6. A roulette wheel system according to any preceding claim, wherein any value that is not evenly distributed is only included in a set of values with at least one other value.

7. A roulette wheel system according to any preceding claim, wherein the uncorrelated sets of values include at least three of the following sets of values:

a) a time at a predetermined game state;

b) a ball and/or wheel position at a predetermined delay from the start of a predetermined game state in which the ball is introduced;

c) a ball and/or wheel position at the start of a state

d) a rotational position of the wheel in combination with a time interval between two states; and

e) a ball position at the start of a predetermined state in combination with a number of revolutions of the ball.

8. A roulette wheel system according to claim 7, wherein the uncorrelated sets of values include at least three of the following sets of values;

a) the time at a predetermined game state is the time at the start of a "place bets"state at the start of a game from the time of the "place bets" state of the previous game;

b) the ball and/or wheel position at a predetermined delay from the start of a predetermined game state in which the ball is introduced is the ball

and the wheel position a predetermined time interval from the start of the "place bets" state;

c) the ball and/or wheel position at the start of a state is the ball and the wheel position at the start of a "no further bets" state at which the ball speed has slowed below a predetermined value;

d) the rotational position of the wheel in combination with a time interval between two states is the rotational position of the wheel at the start of a "winning number" state in which the ball has settled into a pocket;

e) the ball position at the start of a predetermined state in combination with a number of revolutions of the ball is the ball position at the start of the "winning number" state multiplied by a constant plus a count of the total number of revolutions of the ball since the start of the "place bets" state.

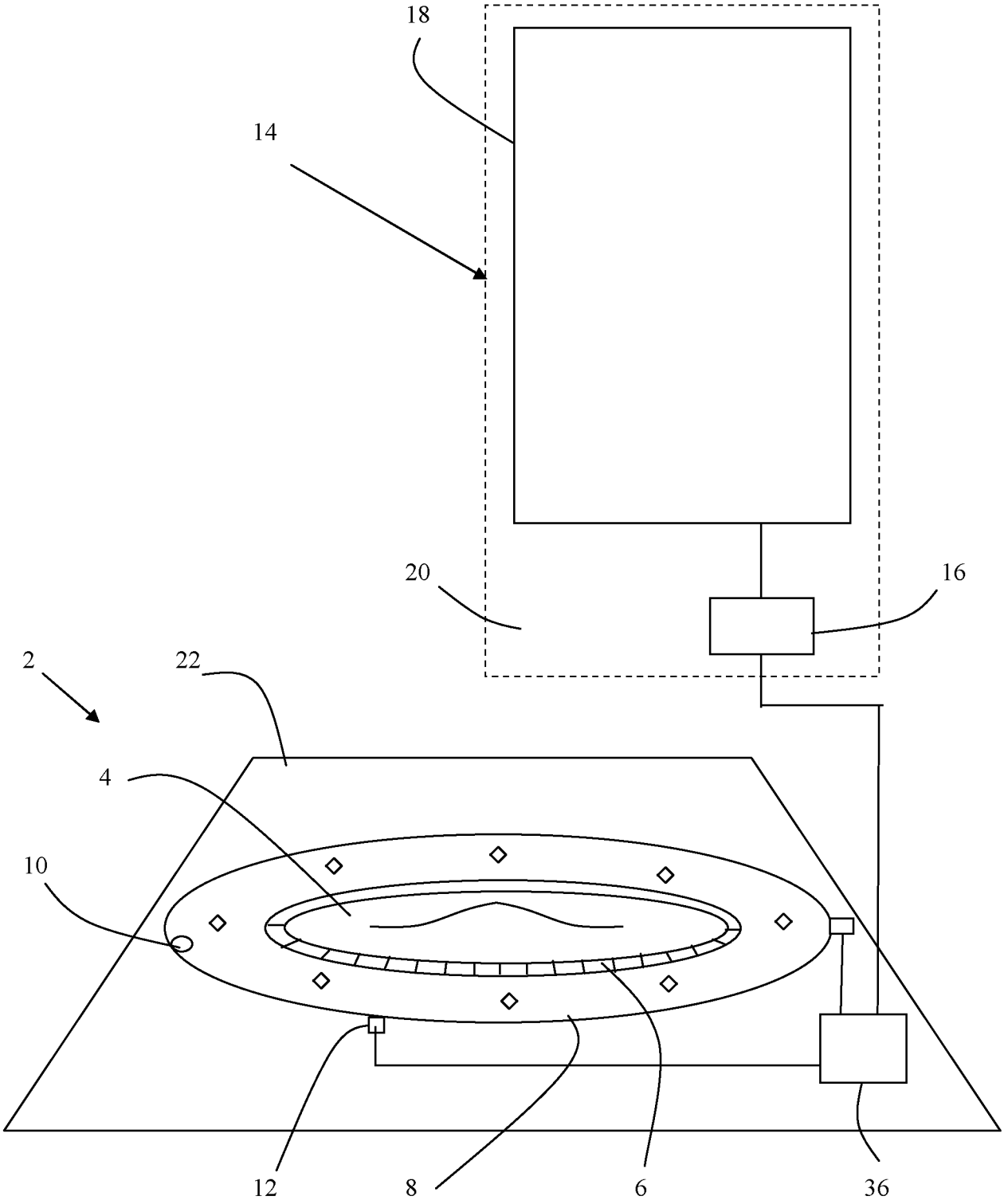

Fig. 1

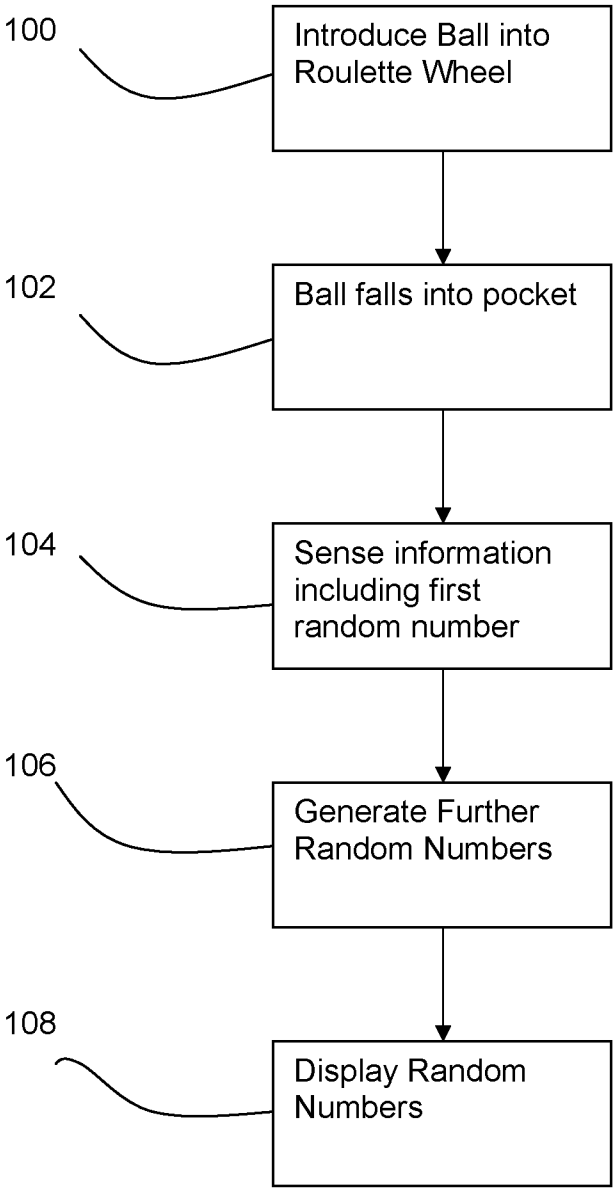
100
Introduce Ball into Roulette Wheel
102
Ball falls into pocket
104
Sense information including first random number
106
Generate Further Random Numbers
108
Display Random Numbers

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050315

A. CLASSIFICATION OF SUBJECT MATTER
INV. A63F5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A63F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 298 422 A1 (CAMMEGH LTD [GB]) 23 March 2011 (2011-03-23) cited in the application paragraphs [0019]-[0023], [0028], [0030] -----	1-8
A	US 2010/164172 A1 (AU-YEUNG CHI FAT [GB]) 1 July 2010 (2010-07-01) paragraphs [0041], [0043] -----	1-8
A	US 2008/252004 A1 (AU-YEUNG CHI FAT [GB]) 16 October 2008 (2008-10-16) paragraphs [0039] - [0041] -----	1-8
A	US 5 540 442 A (ORSELLI THOMAS S [US] ET AL) 30 July 1996 (1996-07-30) column 2, line 66 - column 3, line 12 column 3, line 39 - line 50 column 4, line 41 - column 5, line 20 ----- -/--	1-8

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 April 2013	02/05/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Turmo, Robert

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050315

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	AU 2005 244 551 A1 (STARGAMES CORP PTY LTD) 6 July 2006 (2006-07-06) column 2, line 9 - line 11 -----	1-8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2013/050315

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