

[54] **DEVICE FOR DISPLAYING SYMBOLS
IN A PSEUDO-RANDOM SEQUENCE**[72] Inventors: **Fredric E. Zucker; Joseph Kaswer, Jr.**, both of Stamford, Conn. 06902;
Thomas S. Wilczynski, Trumbull, Conn. 06611[73] Assignee: **Pitney-Bowes, Inc.**, Stamford, Conn.[22] Filed: **Dec. 28, 1970**[21] Appl. No.: **102,005**[52] U.S. Cl. **273/143 R, 340/149 A**[51] Int. Cl. **A63f 5/04**[58] Field of Search.....340/149 A, 147; 235/61.9;
35/3, 4, 2; 273/138 R, 138 A, 143 R, 143 A,
143 B, 143 C, 143 D, 143 E; 74/435[56] **References Cited****UNITED STATES PATENTS**1,515,680 11/1924 Henkels.....35/3
1,978,395 10/1934 Groetchen.....273/143 R2,190,845 2/1940 Nitzberg 273/143 R
3,473,390 10/1969 Brown et al. 74/435 X*Primary Examiner*—Anton O. Oechsle
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Martin D. Wittstein and Louis A. Tirelli[57] **ABSTRACT**

A device for displaying numbers of a pseudo-random sequence. For each change in the number to be displayed, a mutilated gear is rotated by a suitable mechanism through a predetermined angular displacement. For each such rotation, a variable number of teeth of the mutilated gear drive a number wheel through a variable number of numeral display positions. Two different locking elements prevent rotation between actuations. One of the locking elements carries a window shutter which in combination with a second window blocks observation of the number wheel during actuation and reveals the wheel when indexed.

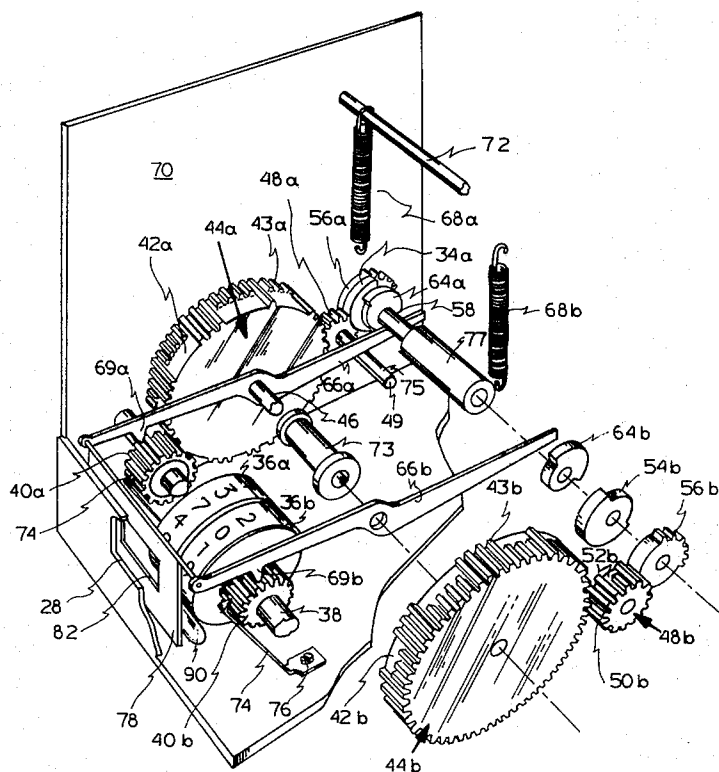
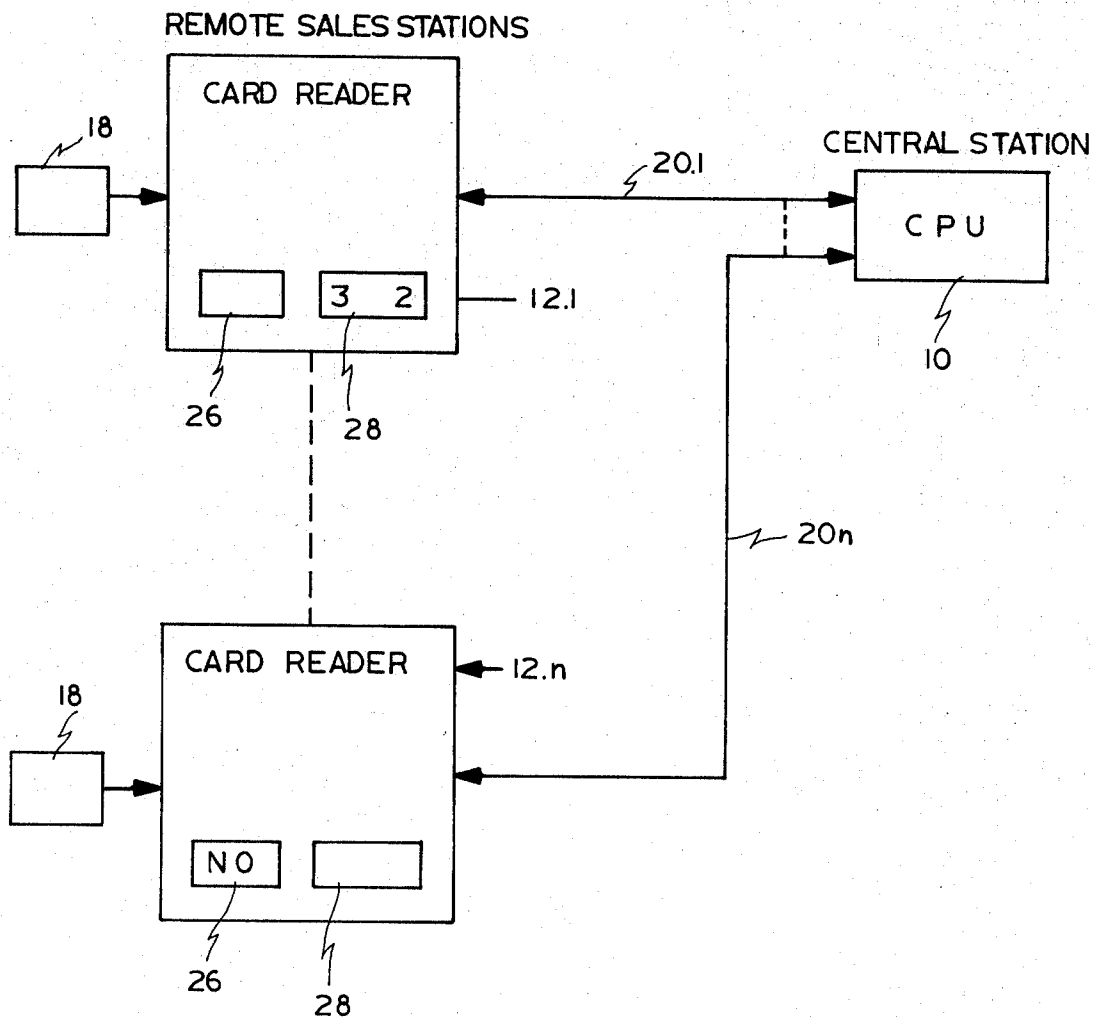
3 Claims, 4 Drawing Figures

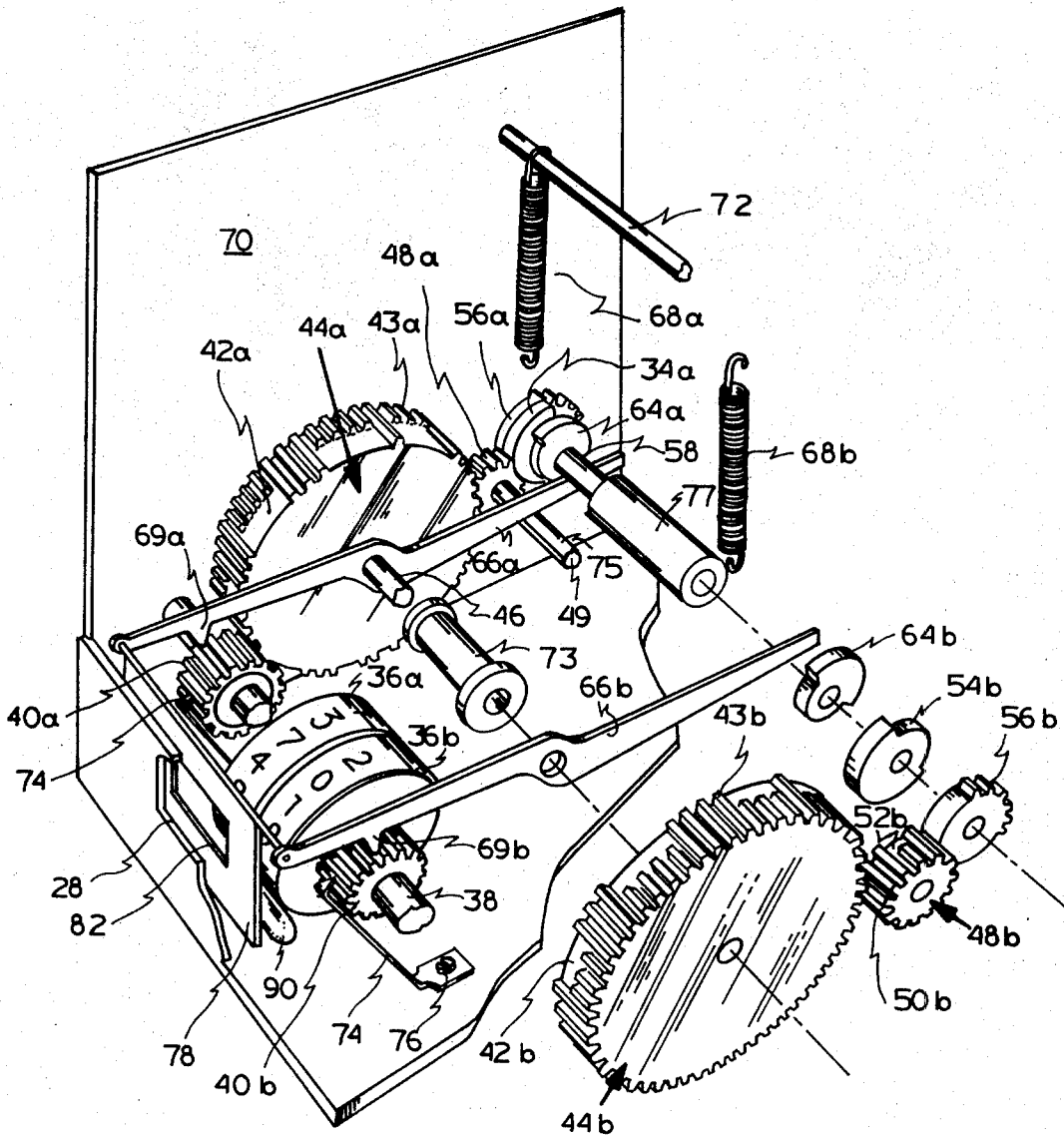
FIG. 1



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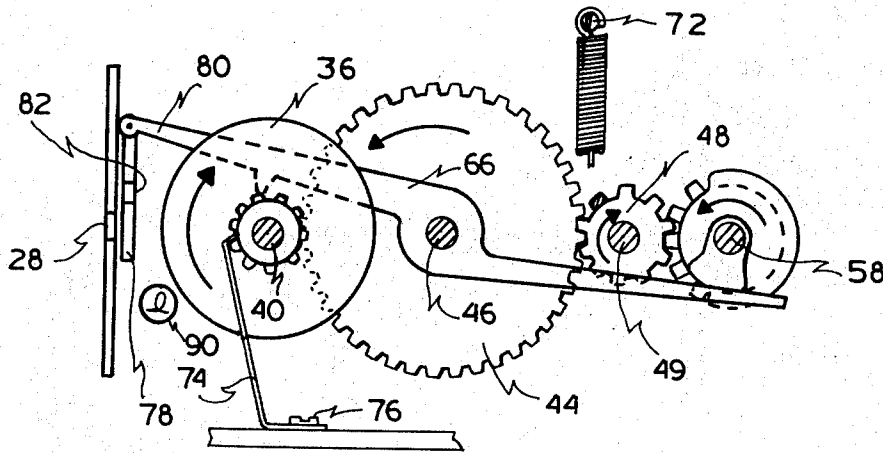


FIG. 4

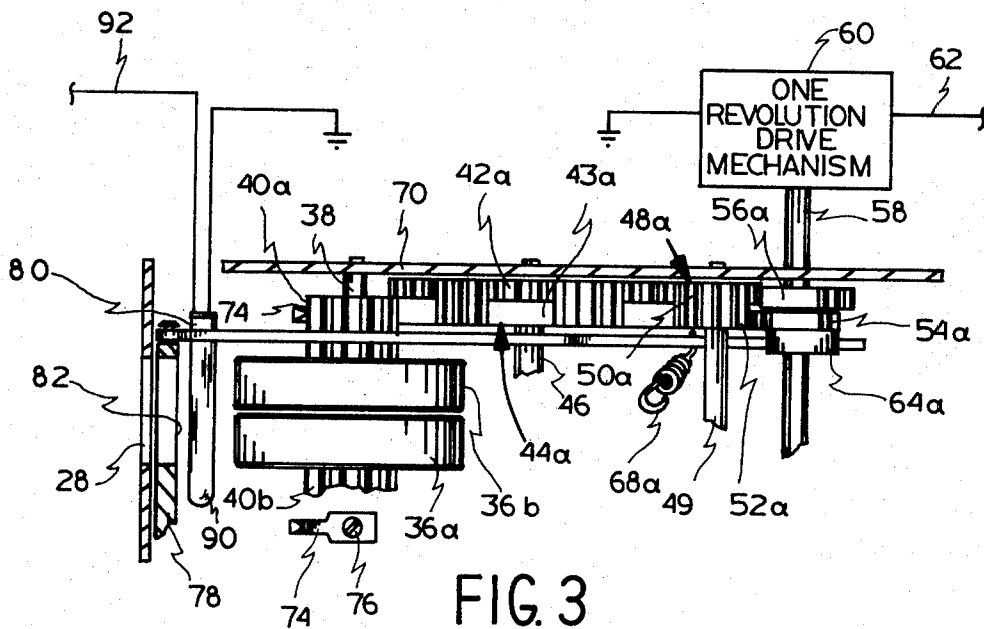


FIG. 3

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DEVICE FOR DISPLAYING SYMBOLS IN A PSEUDO-RANDOM SEQUENCE

FIELD OF THE INVENTION

This invention relates to a device for displaying symbols in a pseudo-random sequence, and to the use of such a device in a credit card verification system.

BACKGROUND OF THE INVENTION

A purely probabilistic device which selects numbers or other symbols in a sequence completely devoid of any predictable pattern, such as a roulette wheel, is a true random number generator. Other random number generating devices, using sophisticated electronic circuitry, are utilized in various statistical analysis problems and for transmitting coded messages; but they are relatively expensive and thus not suitable for applications where cost is a prime consideration.

A device which generates a predetermined but unpatterned sequence of numbers may appear to an observer to be a random number generator, if the predetermined sequence is unknown to him. Such a sequence is necessarily of finite length, however, and must eventually repeat. Therefore, if the observer realizes that the sequence is starting over, he can distinguish it from a random sequence and predict the numbers in the second occurrence of the sequence, based upon his observations of the first occurrence. But this generally will not be possible if the sequence is so lengthy that the observer finds it impractical to detect the eventual repetition. Devices for generating such sequences, which may be referred to as pseudo-random generators, offer a less expensive alternative to random devices in some applications where the appearance of randomness will suffice. In an inexpensive game of chance, for example, a pseudo-random display device might be an acceptable substitute for a roulette wheel, slot machine, or other truly probabilistic device.

Another application for an inexpensive pseudo-random number generator arises in credit card verification systems of the type in which a central computer is connected by telephone or other communication lines to service a plurality of credit card readers located at remote sales stations. Such systems can be defeated by credit card cheats who are able to obtain the collusion of the sales clerk, unless special measures are taken. One such measure is to lay down a trail for subsequent audit, by providing a separate identifying number for each sales transaction, and requiring the sales clerk to record these transaction numbers on the charge slips. But if the transaction numbers must be generated by the central computer and transmitted over long distance phone lines to the sales station for display by the credit card reader, the additional transmission time required, and the extra data reception equipment which must be provided at each of the point-of-sale stations, make the cost excessive.

The cost can be significantly reduced, however, if only a binary accept-reject response is provided by the central computer, and the transaction number is generated right at the sales station. But in order for such a system to operate effectively, the transaction number sequence generated at the sales station must be either random or pseudo-random, so that the collusive sales clerk cannot detect any pattern; otherwise he could correctly predict the next number, and such pre-

dictability would enable him to defeat the system by entering the correct transaction number without consulting the computer and registering the rejection of a fraudulent credit card in its memory. The transaction number generator must also be tamper-proof; and since it will be duplicated at each remote terminal, it should be compact, simple, reliable and inexpensive.

THE INVENTION

This invention concerns a simple, reliable and relatively inexpensive mechanical device which acts as a pseudo-random number generator. The device is suitable for use in a credit card verification system, as well as in simulated games of chance, and is tamper-proof. It includes a display wheel about which the numbers, or other symbols to be displayed, are distributed in a predetermined order. A mutilated gear or gears are provided which are advanced by suitable drive means through a predetermined number of gear tooth positions for each change in the symbol to be displayed. The mutilated gear is then effective to increment the display wheel a pseudo-random variable number of symbol positions.

Another aspect of the invention concerns the use of this or any other type of unpredictable numerical display device to generate a transaction number at a credit card verification station.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram giving an overall view of a credit card verification system according to the teachings of this invention.

FIG. 2 is a partially exploded perspective view of a pseudo-random sequence generating device embodying another aspect of the invention.

FIG. 3 is a top plan view of a portion of the device shown in FIG. 2.

And FIG. 4 is a side elevational view of the same portion of the same device.

The same reference characters refer to the same elements throughout the several views of the drawing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1, the credit card verification system includes a central processing unit (CPU) 10 and a plurality of remote credit card verification stations having respective credit card reader terminals 12.1 through 12.N. Each card reader 12 accepts a credit card 18 having machine-readable numerical subscriber identification information thereon. The particular credit card reading technology utilized may be conventional, and does not form any part of the present invention. The subscriber identification number read from the card is transmitted over an associated one of transmission lines 20.1 through 20.n, which may, for example, be standard telephone lines. The information is received by CPU 10, which determines whether the card is acceptable and may also determine whether the proposed credit transaction is permissible. If the CPU determines that credit should not be granted, it transmits a negative response over the appropriate line 20 to the interrogating station, which causes a light 26 to be turned on in the associated card reader 12 (see reader

12.n, for example). The CPU may handle simultaneous inquiries on a time-sharing or a queuing basis, as desired, using conventional computer programming techniques.

If the credit card sale is acceptable, the card reader illuminates a transaction number, e.g., the number "32" in the example represented by reader 12.1. The transaction number is preferable in the range from 00 to 99, the tens and units digits being displayed on opposite sides of a window 28. The mere presence of this number does not represent a positive response from CPU 10; but its illumination by a lamp 90, seen in FIGS. 2 through 4, does represent a positive response. The transaction number itself is to be copied onto the charge slip by the sales clerk, in order to identify the particular sales transaction for subsequent audit purposes.

This number can be generated in several different ways. If cost were no object, the CPU could generate the transaction number, record it in the computer memory for subsequent audit purposes, and transmit it to the remote terminal 12 for display to the sales clerk. With such a system, the numbering sequence does not matter, because the transaction number which the sales clerk enters on the charge slip can always be compared to the contents of the computer memory, and any lack of correspondence between the two would be evidence of misbehavior. The problem with that system, however, is cost.

A basic insight of the present invention is that it is cheaper to generate the transaction number within the card reader 12 than to receive it from the CPU 10. Not only does this approach avoid the need for additional transmission time, but it also permits the transaction number display device to do double duty by both generating the number and displaying it. In addition, data-decoding and display-driving circuitry are eliminated entirely from the remote terminal 12.

On the theory that the mere appearance of traceability may be sufficient to discourage wrongdoers, the internally generated transaction number may be a fake; i.e., it may not represent an actually traceable audit trail, provided the dishonest sales clerk does not know that.

One way to generate a fake sequence of transaction numbers is to incorporate a true random number generator within the card reader 12. But this requires sophisticated electronic circuitry at each sales station, and is therefore expensive. Moreover, a true random number system, or any other system which is completely untraceable, relies entirely on the prior deterrent effect of fear of detection. If the fake nature of the system ever became known, the dishonest sales clerk would no longer be deterred by fear of detection, and there would be no way to perform a subsequent audit.

If the internally generated transaction number is not truly random, however, some way must be devised to make sure that it cannot be predicted by the sales clerk; because if he fabricates a false transaction number to make a fraudulent sale look authentic, the CPU will not have a stored check-list of transaction numbers usable to discover the subterfuge.

In accordance with the preferred embodiment of this invention, each card reader 12 displays an internally generated pseudo-random sequence of transaction

numbers which, for all practical purposes, is just as difficult to predict as a truly random one. It accomplished this, preferably, by employing a compact simple, reliable, low cost mechanical sequence-generating device of the type illustrated in FIGS. 2 through 4. The tens and units digits to be display at window 28 are carried on two number display wheels 36A and 36B respectively, located on opposite sides of the device. These wheels are mounted for rotation, independently of each other, about a common shaft 38. The drive mechanisms for the wheels 36A and 36B are substantially identical, so that in the discussion to follow only general reference numerals need be utilized, it being understood that the indicated element may be that for either the A or B side of the device.

In the discussion which follows, there are references to the "effective" number of teeth on various driving gear members. This term is intended to designate the actual number of tooth increments of angular displacement imparted to driven gears by driving members having discontinuous gear tracks, such as gear sectors or mutilated gear tracks. When two full-track gears are in mesh for 360°, the effective number of teeth is equal to the actual number; but when the driving gear track is discontinuous, special effects may occur upon engagement and disengagement, which cause N teeth on the driving gear member to impart less than N tooth increments of angular displacement to the driven gear member. Such effects depend upon the geometry of the gear teeth, specifically their "contact ratio;" see "Standard Handbook for Electrical and Mechanical Engineers" by Marks.

Each of the wheels 36 has a plurality of numerals uniformly spaced about its periphery. In order to enhance the apparent randomness of the number display sequence, the digits 0 through 9 are in random rather than numerical order on each of the wheels 36; and, in a preferred embodiment of the invention, some of the digits appear more than once on each wheel so that there is not an equal probability of occurrence.

A final drive pinion 40, having a number of teeth N_{40} equal to the number of digits distributed about the corresponding wheel 36, is attached to each of the wheels 36 so that rotation of a pinion 40 about shaft 38 drives the associated wheel 36. Each pinion 40 is driven by a mutilated gear track 42, i.e. one with a number of teeth missing, formed on one side of an intermediate drive gear 44. The directions of rotation of pinion 40 and all other elements are indicated by the arrows in FIG. 4. In the particular embodiment illustrated N_{40} is 12.

The other side of the gear 44 is full-toothed gear track 43, the number of teeth N_{43} on which is preferably a relatively large prime number. For the particular embodiment of the invention illustrated here, $N_{43}=73$. The exact value of N_{43} is not critical, but a prime number of teeth should be utilized, and it should be relatively large, since the magnitude of this number and its "primeness" are factors which determine the number of times the display can be operated before the number sequence repeats. Both gears 44 are mounted for rotation on a shaft 46, and may either be free to rotate independently thereon as shown in the drawings, or keyed to the shaft to rotate together.

The mutilation of gear track 42 is achieved by removing some teeth, and not removing others, in a

random, non-repetitive, unpredictable sequence. In operation the gear 44 is advanced (by means discussed in detail subsequently) through a predetermined number of tooth increments N_{56} (in the range from 2 through $N_{43}-1$) each time that the numerical display is to be changed. In the specific example illustrated, N_{56} is 7; but the exact number is not critical so long as it remains in the range indicated, which in this case is from 2 through 72.

Each time gear 44 rotates through seven teeth positions, some random effective number of teeth of its mutilated track 42 engage with the associated pinion 40. This number will depend on how many teeth happen to be missing from the particular sector of track 42 which is currently in position to drive pinion 40. Thus, for each cycle of operation each of the pinions 40 will be advanced by a number of tooth positions which varies from cycle to cycle in a pseudo-random fashion. Since each tooth of pinion 40 corresponds to one numeral position of the associated number wheel 36, the number wheel will advance a number of numeral positions equal to the number of tooth positions by which its pinion 40 is advanced. Thus the number of numeral positions by which each display wheel advances also changes pseudo-randomly from cycle to cycle.

Because the number of teeth N_{43} in the unmutated track 43 of gear 44 is a prime number (73), starting from any initial position the gear 44 must be advanced through $N_{43}=73$ consecutive operating cycles of seven tooth increments each (or $N_{56}=7$ revolutions) before it comes to rest again at that same position, and the cycle starts over. Since gear 44 goes through $N_{43}=73$ different operating cycles, and the pinion 40 driven thereby has $N_{40}=12$ teeth, the pinion and its number wheel 36 go through $N_{43} \times N_{40} = 73 \times 12 = 876$ different cycles before repeating; provided N_{42} (i.e., the effective number of unmutated teeth) in the mutilated gear track 42 times the number of revolutions which gear 44 goes through before repeating (in this case seven) equals a quantity which has no factors in common with (i.e., is "prime" relative to) N_{40} . Thus, if the mutilated track 42 is designed to observe this requirement, there is an 876 cycle interval before repetition. A non-repetitive sequence of that length is so time-consuming to observe, and so difficult to keep in mind, that most people will have enormous difficulty in detecting and using the repetition of the sequence to predict the next digits to be displayed by the wheels 36.

The reader's attention is directed next to the mechanism for incrementing gear 44 by $N_{56}=7$ teeth for each operating cycle. Each of the gears 44 is driven by an intermediate pinion 48 which, as best seen in FIG. 3, has a full-toothed track 50 of any convenient number of teeth on one side for driving the full-toothed track 42 of gear 44, thus a seven-tooth advance of pinion 48 will produce the desired seven-tooth advance of the associated gear 44.

The remainder of the drive mechanism constitutes a means to produce a seven-tooth advance of pinions 48 during each operating cycle, while confining that advance to a fraction of the cycle time. Pinions 48 are mounted for rotation on a common shaft 49. One side of each pinion 48 comprises a gear track 52 with one tooth missing. The tooth gap in each track 52 first receives the high lobe of a Geneva cam 54, to lock the

gear train 48, 44 against rotation during the first phase of each operating cycle, i.e. until the toothed sector of a driving gear 56 is in position to engage the full-toothed track 50 of the pinion 48. Then a low dwell of the Geneva cam 54 rotates into position adjacent the pinion track 52, unlocking the pinion 48 to permit rotation of the gear train. The desired seven-tooth advance of pinion 48 during this phase of the operating cycle is achieved by providing the driving gear 56 with an effective number of teeth $N_{56}=7$, all of which are grouped together along a limited sector of its circumference. If desired, the effective number of teeth N_{56A} and N_{56B} in gears 56A and 56B could be different, which would make the number sequence even more difficult to detect.

Geneva cam 54 and drive gear 56 are both keyed to drive shaft 58 which, as may be seen in FIG. 3, is connected to a one-revolution drive mechanism 60. When the CPU 10 of FIG. 1 approves a credit sale, a signal is applied to an electrical line 62, indicating that the number displayed in window 28 is to be changed, and causing mechanism 60 to rotate the drive shaft 58 one revolution. The particular construction of mechanism 60 does not form part of the present invention, and any conventional means for performing this function may be utilized. The CPU at this time also initiates a signal on an electrical line 92, to light lamp 90, indicating the approval of the credit sale.

One reason for confining the rotation of pinion 48 and the remainder of the number wheel drive train to a fraction of the cycle time of drive shaft 58, is to permit that shaft to be used also as the main timing shaft of the entire credit card reader device 12 (FIG. 1), which drives other rotary equipment during each operating cycle before and/or after changing the transaction number display. Another reason is to allow a certain amount of coasting tolerance for the drive mechanism 60, while still assuring that it will drive the transaction number display device of this invention through the same angular increment of seven teeth each time it is operated. A third reason, relating to shutter 78, is discussed below.

In addition to the Geneva cam 54 and drive gear 56, shaft 58 also has keyed thereto a cam 64 for each of the display wheels. The rear end of each pawl arm 66, which is pivotably mounted on shaft 46, is biased upwardly by a tension spring 68 to bear against the associated cam 64. The upper ends of springs 68 are anchored to a shaft 72. When the arm 66 is against a low dwell of cam 64 (as seen in FIG. 2), the forward end of the arm is so positioned that a pawl tooth 69 formed thereon engages the teeth of the associated pinion 40, to lock the pinion and the associated number wheel 36 against rotation. This situation occurs when the transaction number display is not in the process of being changed. When it is being changed, as seen in FIG. 4, a high lobe of cam 64 comes into contact with arm 66, raising the pawl 69 out of engagement to permit rotation of the pinion 40 and number wheel 36. This feature helps to prevent tampering with the number display generator, by preventing any unauthorized rotation of the number wheels.

Shafts 38, 46, 49, 58 and 72 are all supported between the walls of a metal frame 70. If the various gears are keyed to, but slidable on, the shafts 46, 49 and 58, respective spacers 73, 75 and 77 are provided.

In order to prevent the sales clerk from detecting the sequence in which the numerals appear on wheel 36 as it is moving, which might give him a somewhat greater probability of prediction, shutter 78 is attached to forward extension 80 of both pawl arms 66. The shutter is formed with an aperture 82, and the window 28 and aperture 82 are so proportioned that only one of the numerals on each wheel can be seen at one time. The aperture is aligned with window 28 (see FIG. 2) only when the number display is not changing. While the display is changing, shutter 78 is raised to block window 28 (FIG. 4), preventing the operator from seeing the rotation of the wheel. After each display has been completed, arms 66 are permitted to drop down again, realigning the shutter aperture 82 with window 28 to permit viewing of the number display, provided the lamp 90 is lit by a signal from the CPU 10. Thus the Geneva mechanisms 54, 52 discussed above cooperate with the cams 64 to divide each cycle of drive shaft 58 into separate time intervals for changing and revealing the display, respectively.

Alternatively, the lamp 90 could be lit at all times when the card reader 12 is in operation, and the shutter 78, instead of being actuated by the drive cams 64, could be raised or lowered by a conventional solenoid mechanism (not shown) responsive to signals from CPU 10. In that case, mere visibility of the transaction number display would constitute the computer-generated approval signal for each credit sale.

An additional feature which improves the security of the device relates to the prevention of reverse number wheel rotation. Anti-reverse pawls 74, bent from resilient sheet metal and secured to the floor of frame 70 by fasteners 76, engage each pinion 40. The pawls are self-biased into engagement with the pinions, and angled upwardly so as to lock when an attempt is made to turn the pinions counter-clockwise as viewed in FIG. 4. The pawls yield resiliently, however to ratchet over the pinions 40 and permit easy rotation in the clockwise direction.

It is not necessary that the mutilation pattern on the two gears 44 be completely different. Instead, in order to reduce the cost of manufacturing this device, the gears 44A and 44B are preferably identical but flipped-over relative to each other, so that their mutilation patterns progress in opposite sequence, in effect providing two entirely different mutilation sequences. Furthermore, while separate drive trains have been shown for each of the mutilated gears 44, if the gears 44 are both keyed to shaft 46 only a single drive train 50, 56 and a single Geneva mechanism 52, 54 may be required.

While two digit positions (units and tens) are employed in this embodiment, a lesser or greater number of digit positions could be provided as required. It should be noted, however, that the more digit positions there are in the transaction number, the lower is the probability that a prospective wrongdoer will be able to guess the entire number, because all the digits proceed independently through their respective pseudo-random sequences.

Finally, it should be noted that a pseudo-random device of this kind has an additional very important advantage for use in a credit card verification system. The actual transaction number sequence, however long it may be, and however many digit positions are employed, is still actually predetermined and predictable,

if only the observer had the time and capacity to perform the necessary observations and calculations. Modern computers, which are able to compress time through their great calculating speeds, and also have the memory capacity to handle a great deal of data, can do it. The CPU 10 of FIG. 1, therefore, when properly programmed and provided with information as to the sequence of numerals on display wheels 36, the number of teeth on each gear and pinion in the drive train, and the exact mutilation pattern and angular directions of gear tracks 43, can actually calculate the entire 876 member sequence of two-digit transaction numbers, and thus provide a true basis for subsequent audit if one should be necessary.

Alternatively, a true audit can be provided without the need for as much computer software, if the display output shafts 38 drive conventional commutating switches (which can be plated on the sides of number wheels 36, if desired) to provide digitally encoded feedback indicating to the CPU 10 which numbers were displayed.

It will now be appreciated that the present invention provides pseudo-random number generation, which is especially useful for both generating and displaying transaction numbers at the remote terminals of a credit card verification system, avoiding the need for deriving such numbers from the central computer station, and which also is able to lay down a true audit trail.

Since the foregoing description and drawings are merely illustrative, the scope of protection of the invention has been more broadly stated in the following claims; and these should be liberally interpreted so as to obtain the benefit of all equivalents to which the invention is fairly entitled.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A device for displaying symbols in pseudo-random sequence: comprising
 - a frame;
 - a main drive shaft rotatably mounted in said frame;
 - wheel display means rotatably mounted on said frame;
 - gearing means including at least one mutilated gear for interconnecting said drive shaft and said wheel display means so that said display means may be rotated through varying angles dependent upon the mutilated pattern of said gear;
 - a first locking means movable into and out of positive locking condition with respect to a first portion of said gearing means;
 - a second locking means movable into and out of positive locking condition with respect to a second portion of said gearing means; and
 - cam means driven by said main drive shaft for moving both of said locking means out of their respective locking conditions when said drive shaft is to rotatably index said wheel display means.
2. Apparatus as defined by claim 1 wherein said wheel display means includes two display wheels, and said gearing means includes two separate gear trains functionally arranged in parallel relation and each driven directly from said main drive shaft to rotate a respective display wheel.

3. Apparatus as defined by claim 1: additionally comprising shutter means mounted on said frame for movement into and out of view blocking position with respect to said display wheel means; and said cam means including actuating means operated in timed relation to the rotation of said main drive shaft for moving said shutter means into and out of said view blocking position.

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