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RANDOM DIGIT GENERATOR

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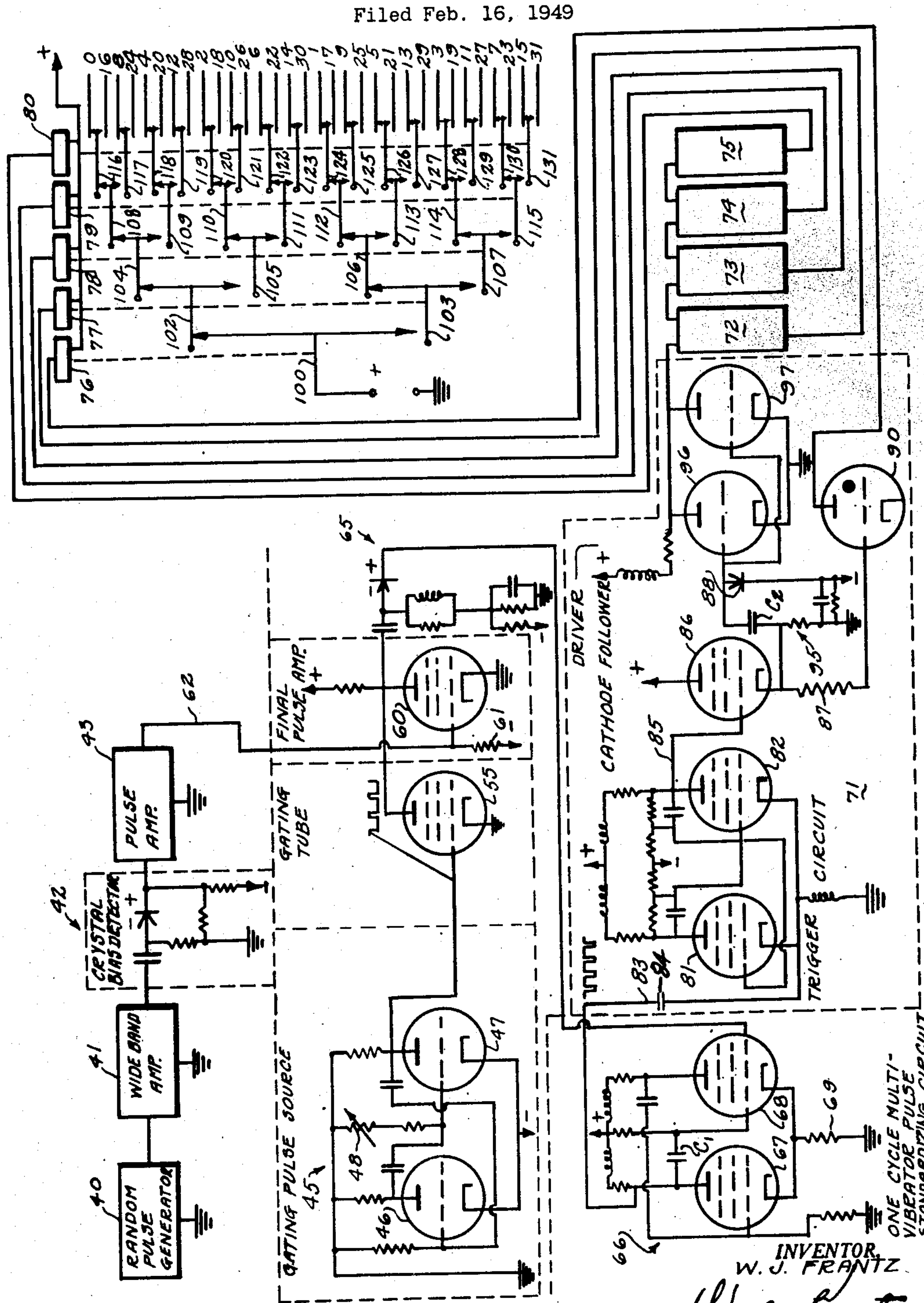

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RANDOM DIGIT GENERATOR

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1

This invention relates to a device for providing a selection of digits or numbers with a high degree of randomness.

The solution of statistical problems by the method of experimental probability calculation may require a great quantity of random digits. Limited tables of random numbers have been published but much larger tables are needed to avoid using the same tables over and over again. Repetitious use of a table of random numbers is particularly undesirable in a single problem. It has been shown repeatedly that an individual, making what is purported to be random selections of digits or numbers, does not make actual random choices although the individual is completely unconscious of the existence of any bias or of being influenced.

The present invention provides a device for selecting digits or numbers purely at random by utilizing the "shot effect" of a conducting vacuum tube, or pulses of any other generated source which has been found to produce pulses at random. A gating circuit controlled by a constant frequency pulse generator cuts the random pulses on and off in groups of predetermined equal periods of time. Each random pulse advances the position of a counter one digit so that each group of random pulses advances the count many thousand digits. After each group of pulses, the digit or number at which the counter rests is considered to be randomly chosen.

The major advantage of this system over most other attempts at selecting digits or numbers at random is the impartiality of this system in making selections since, theoretically, the counter has no choice but to advance exactly one step for each random pulse received and since, theoretically, the counter has no influence upon either the arrival of driving pulses or the closing of the gate circuit.

It is a primary object of this invention to provide a device that will make random digit or number selections.

It is another principal object of this invention to provide a device for utilizing generated random frequency pulses to provide random digit or number selections.

It is still another object of this invention to provide a random digit or number generator in which random pulses produced by a random pulse generator source are gated in groups by a gating circuit, the random pulses of which advance a counter at a random rate wherein the final resting place of the counter at gate closing will be a digit or number chosen at random.

2

It is still a further object of this invention to provide a random digit or number selecting device in which a counter circuit, including a plurality of trigger circuits coupled serially and constructed to each operate at half the speed of the preceding trigger circuit and each trigger circuit is coupled to a relay, is operative to indicate selected digits or numbers, all the relays of which determine which one of a plurality of contacts, each representative of a digit, will be connected to a power source, the first trigger circuit being driven by standardized amplitude random frequency pulses and the succeeding trigger circuits being driven by the preceding trigger circuit, the standardized amplitude random frequency pulses being controlled to be cut off by a gating pulse at predetermined times such that the contact, representative of a number, rested on at the time of pulse cut off is the random selected number.

These and other objects and advantages will become more apparent as the description proceeds when taken in view of the accompanying drawing in which various parts of the circuits and elements are shown in detail and other elements are shown in block diagram for simplicity and clarity of the invention.

Referring now to the drawing, there is shown a random pulse generator 40 of any desirable type, as a conducting vacuum tube in which the random arrival of electrons at the plate produces a "shot effect" that causes a fluctuation about the average value of plate current. The output of the random pulse generator is coupled through a wide band pass amplifier 41 to a network 42. This network 42 contains a crystal detector so biased as to pass only those negative voltage peaks in the output of the amplifier which are more negative than a predetermined value determined by the bias on the crystal detector and large in magnitude compared to the root-mean-square value of the voltage fluctuation. As the bias value is increased, the expected number of peaks per second exceeding the bias value decreases.

The occurrence of these high peaks is not entirely random since such peaks could be random only if the band width of the amplifier were infinite. The voltage output of an amplifier with a finite band width depends not only upon the instantaneous impressed voltages, but also upon voltages impressed in the past. Therefore, the fact that one voltage peak greater than the bias value occurred at a given time would appreciably affect the voltage output of the amplifier for a certain length of time following the given time, the effect, of course, being a decaying function of time. Thus, if the amplifier has a transient response characteristic which expends itself within a time delta-*t*, it can be reasonably assumed that the distribution of voltage peaks greater than the bias value is random except during the very short time interval delta-*t* following each such peak. That is, the bias value is as likely to be exceeded at one time as another except within the time delta-*t* of the previously occurring peak. A well constructed wide band-pass amplifier has a negligible transient decaying time which has been found to be 10^{-7} second and less. The effect of this transient decaying time, though its existence is known, does not provide any harmful results in the ultimate selection of random digits, and, as will be seen later in the description, the existence of the "dead spot" caused by the transient decay time in the wide band pass amplifier **41** will be immaterial.

The peaks, or pulses, from the detector **42** output are passed through a pulse amplifier **43** of the designed number of tubes to provide amplified positive output pulses.

Another generated pulse source is used to produce an approximately constant frequency for gating the noise or random output pulses. This pulse source is shown and illustrated as a single unsymmetrical multivibrator **45** including two triodes **46** and **47**. The time constant circuit of this multivibrator, which includes a variable resistor **48** for adjusting the wave width, is so adjusted that the rectangular wave produced at the anode of tube **47** has its minimum value for about nine-tenths of a second and its maximum value for about one-tenth of a second. This wave is applied to a gating tube **55**. The gating tube **55** is cut off during the nine-tenths of a second in which the grid potential has its minimum value. During this period, a final pulse amplifier **60**, having its anode coupled to the anode of the gating tube **55**, is in an operative condition and passes the random pulses from the amplifier **43** applied to its grid. For one-tenth second during which the grid potential of tube **55** has its maximum value, the tube **55** lowers the anode potential of tube **60** sufficiently to render tube **60** inoperative.

The output of the final pulse amplifier **60** is connected through a crystal detector **65**, which passes negative pulses, and thence to the grid of tube **68** in a one-cycle multivibrator pulse standardizing circuit **66** which includes two tubes **67** and **68**, and has a stable condition in which tube **68** is conducting and tube **67** is cut off by the drop across a resistor **69**. The application of a negative pulse to the grid of tube **68** cuts this tube off and renders tube **67** conductive due to the rise in voltage on its grid which is coupled to the anode of tube **68**. The one-cycle multivibrator remains in this condition until the grid of tube **68** has risen above the cut-off point due to the discharging of condenser C_1. When this occurs, the circuit rapidly returns to its stable condition in which tube **67** is cut off and tube **68** is conducting. In going through the above described cycle, a short negative rectangular pulse is produced at the anode of tube **67**. Therefore, each pulse applied to the grid of tube **68** that is of sufficient amplitude to trigger the one-cycle multivibrator circuit causes the production of a negative pulse of fixed amplitude and duration. The one-cycle multivibrator pulse standardizing circuit **66** therefore rejects all pulses below a certain amplitude and standardizes the remainder. It is essential that a pulse of marginal intensity (marginal so far as its ability to drive a counter is concerned, later to be described) be either eliminated or increased to an intensity that is certain to advance the counter one step. The one-cycle multivibrator pulse standardizing circuit is the ultimate limitation upon the rapidity with which successive random pulses can be accepted. The circuit requires about one microsecond to act and return to its equilibrium position. If any other pulses come through the gate circuit in that interval of time, they are disregarded. The dead interval caused by the one-cycle multivibrator actually blankets the "dead spot" produced by the wide band-pass amplifier **41** such that only one discrepancy occurs in the random pulse path, the effect in the final results which will later de described.

A thirty-two digit counter is associated with the one-cycle multivibrator pulse standardizing circuit **66** to operate in accordance with the standardized random pulses received from this multivibrator circuit **66**. The counter comprises five serially arranged binary control circuits **71**, **72**, **73**, **74** and **75** that are connected respectively to five corresponding relays **76**, **77**, **78**, **79** and **80**. Since all of the binary control circuits are essentially alike, only the binary control circuit **71** is shown in detail and will be described. The binary control circuit **71** includes a trigger circuit of the Eccles-Jordan type having two tubes **81** and **82** which have their cathodes connected to the plate of tube **67** of the one-cycle multivibrator pulse standardizing circuit **66** through conductor **83** having a condenser **84** therein. The two tubes **81** and **82** are connected in a regenerative loop so that the circuit has two conditions of stability in each of which one of the tubes is conductive and the other is cut off. The application of a negative pulse simultaneously to the cathodes of the two tubes wil trigger the circuit from either condition of stability to the other stable condition. Hence, each standardized random pulse which is applied to the cathodes of tubes **81** and **82** by conductor **83** triggers the primary control circuit **71**. For example, and for the purpose of illustration, let it be assumed that tube **81** becomes conductive upon the first random negative pulse being impressed on the cathodes of both tubes. A second random negative pulse, then, will effect conductivity in tube **82** and bias the tube **81** below cut-off. The output of the trigger circuit is taken from the anode of the tube **82**.

The anode of the tube **82** is connected by conductor **85** to the grid of a cathode follower tube **86**. The cathode of the tube **86** is connected through a resistor **87** to the grid of a thyratron tube **90**, the plate of which is connected in circuit with the relay **76** such that whenever the tube **82** is nonconducting the cathode voltage of tube **86** will have its maximum value causing the grid of the thyratron tube **90** to reach a voltage sufficient to produce a condition to energize the relay **76**.

The cathode of tube **86** is also connected through a condenser C_2 to the grids of parallel connected tubes **96** and **97**. A crystal rectifying element is connected in shunt to the grid circuits of these tubes and poled to allow the application of positive, but not negative, pulses to the grids. In addition to its blocking action, the condenser C_2 acts as a differentiating device for producing sharpened pulses from the edges of the rectangular pulses on the cathode of tube **86**. In this way, the leading edges of the square pulses at the cathode of tube **86** result in sharp positive pulses on the grids of tubes 96 and 97 whereas the negative pulses resulting from the trailing edges of the rectangular pulses have little or no effect on the tubes due to the action of the crystal rectifying element 88. The resulting negative pulses appearing on the anodes of tubes 96 and 97 are applied to the cathodes of the two tubes in the trigger circuit contained in the binary control circuit 72 corresponding to the trigger circuit tubes 81 and 82 and serve to trigger this binary control circuit in the same manner as described in connection with the trigger circuit of the binary control circuit 71. The binary control circuits 72, 73, 74 and 75 are all identical to the binary control circuit 71 with the exception that the binary control circuit 75 does not have the crystal network 95 or the two driver tubes 96 and 97. With the five binary control circuits coupled in the manner described the trigger circuit of the second binary control circuit 72 reverses once for every two reversals of the trigger circuit in the first binary control circuit 71; the trigger circuit in the third binary control circuit 73 operates at half the speed of the second binary control circuit 72; etc. since it is the positive leading edge of each signal impressed on the cathodes that flips the trigger circuit from one to the other condition of stability. There are, therefore, 25 or 32 different combinations of the trigger circuits in the five binary control circuits which will set the five relays 76 to 80 likewise in thirty-two different resting positions. Thus, as the first binary control circuit 71 is driven by pulses from the one-cycle multivibrator pulse shaping circuit 66, the succeeding binary control circuit 72 would receive a pulse whenever the trigger circuit tube 82 becomes nonconductive; the third binary control circuit 73 would receive a pulse whenever a tube, corresponding to the tube 82, in the trigger circuit of the binary control circuit 72 becomes nonconductive; and so on through all five binary control circuits.

The relays 76–80 are such that the armature is biased to normally rest in one position when the relay is de-energized. The relay 76 has its armature mechanically connected to a switch blade 100 having oppositely faced contacts adapted to engage switch blades 102 and 103 both of which are under the control of the relay 77. Likewise, switch blades 102 and 103 each have oppositely faced contacts engageable with switch blades 104, 105 and 106, 107, respectively, the switch blades 104–107, inclusive, being under the control of the relay 78. The switch blade 104 alternately contacts switch blades 108, 109; switch blade 105 alternately contacts switch blade 110, 111; switch blade 106 alternately contacts switch blades 112, 113; and switch blade 107 alternately contacts switch blades 114, 115. The switch blades 108–115 are all actuatable by the relay 79. A similar relation is obtained with switch blades 108–115 with corresponding switch blades 116, 117; 118, 119; etc. through 130, 131, the blades 116–131 being actuatable by the relay 80. Switch blade 116 through 131 is adapted to make contact between corresponding stationary contacts 0, 16; 8, 24; 4, 20; 12, 28; 2, 18; 10, 26; 6, 22; 14, 30; 1, 17; 9, 25; 5, 21; 13, 29; 3, 19; 11, 27; 7, 23; and 15, 31, respectively. It may be readily seen that there can be only one completed circuit to the common terminal switch blade 100 for each combination of the five relays of the binary control circuits producing thirty-two possible paths. The stationary contacts 0 to 31 may each be connected in circuit to lights to illuminate numbers from 0 to 31 or other visible means of indicating the digit or number selected at random. It is also within the scope of this invention that the stationary contacts can be connected in a circuit to punching means of a duplicating punch machine that is capable of constructing tables of random numbers automatically, or any other device to be operated from random number selections.

The circuit may be tested by blocking the supply of random driving pulses by biasing one of the pulse amplifier tubes far beyond cut-off. If no random driving pulses are supplied, the count should advance exactly one step for every cycle of the gating pulse source 45 since the leading edge of the gating pulse is itself sharp enough to drive the one-cycle multivibrator pulse standardizing circuit 66. By observing the numerical sequence, the failure or erratic operation of the gating pulse generator, the counter circuits, the thyratrons, or the relays can be detected.

The numbers 0 to 31 corresponding to the stationary contacts are arranged such that the random pulses, under the conditions in which the trigger circuits would initially rest in a stable condition wherein the tube 82 of each circuit is conductive, would advance the counter in a numerical sequence. For instance, the unenergized position of the relays 76–80 form an electrical path through 101, 102, 104, 108, 116 and 0; one pulse effects pull of the switch arm 100 downward to provide a path through 100, 103, 106, 112, 124 and 1; a second pulse allows the switch arm 100 to return to the normal upward position but relay 76 is energized to pull switch arms 102 and 103 down whereby an electrical path is established through 100, 102, 105, 110, 120 and 2; and so on through all the thirty-two different combinations possible in the trigger circuits. Where the trigger circuits, upon being energized, initially rest in unlike stable positions, the relays 76–80 will rest in corresponding various positions and succeeding pulses will produce a ring sequence of numbers that will repeat through each combination of the thirty-two positions. At any event, the digit or number upon which the counter rests at the end of each group of pulses is the random selected number.

Where it is desirable to get only digit selections from 0 to 9, the stationary contacts as 0, 10 and 20; 1, 11 and 21; 2, 12 and 22; etc. up to 9, 19 and 29; may be connected in parallel, discarding the numbers 30 and 31.

In operation, the various circuits have operating voltages applied thereto through a master switch (not shown) in the generally provided well known manner. After a short time, the several tubes come to their thermal equilibrium condition and the random noise generator produces random pulses and the peaks of such pulses lying in magnitude above a predetermined biased value of the crystal biased detector 42 are amplified and impressed on the grid of the final pulse amplifier tube 60.

The gating pulse generator 45 produces a series of equally spaced positive pulses all having equal lengths of from four-tenths to one second depending on the adjusted position of resistor 48. Thus, pulses are applied to the grid of the tube 55 as a pulse in the negative direction which cuts this tube off for the duration of the pulse, allowing the anode voltage of tube 60 to rise and this tube to become operative. During the interval between pulses, tube 55 is conducting and lowers the anode voltage of tube 60 sufficiently to render this tube inoperative. This action results in groups of random pulses being applied to the pulse standardizing circuit 66 at regular intervals. The standardized pulses issuing from the one-cycle multivibrator standardizing circuit 66 are impressed on the trigger circuit of the first binary control circuit 71.

When the operating voltages were first applied to the device, the trigger circuit in the binary control circuit 71, as well as in the control circuits 72–75, assumed one condition of stability in which those trigger circuits become stable, with tubes corresponding to tubes 82 becoming conductive, the respective relay would be de-energized; and for those trigger circuits becoming stabilized with tube 81 becoming conductive, the relay corresponding to these trigger circuits would be energized and the contacts controlled thereby switched. One path would be established to one of the contacts 0 to 31. For each standardized amplitude random frequency pulse received at the cathodes of tubes 81, 82 of the first binary control circuit 71, the relay 76 is changed to switch the contacts 102, 103. For every two reversals of the trigger circuit in the binary control circuit 71, the trigger circuit in the binary control circuit 72 will be changed to switch the relay 77 switching the contact 104, 105 and 106, 107, and so on for the standardized amplitude random frequency pulses received. When the standardized amplitude random frequency pulses are cut off, the relays will all be positioned to establish an electrical path to one of the contacts 0 to 31 providing a random chosen number. Since the random pulses occur at the rate of about one hundred thousand pulses per second, the counter operates through many numbers before resting at the end of each group of pulses applied thereto. Since the randomness of pulses is not influenced by the counter and the counter is isolated from the random and gating frequency generators by circuit 66, the digit or number selected is considered to be a random number. The only "dead spot" in the system occurs, as pointed out earlier in the description, within one microsecond of a previously accepted pulse in the one-cycle multivibrator pulse standardizing circuit 66 which also blankets the one tenth microsecond dead interval occurring after each random pulse in the wide band amplifier 41. The "dead spot," however, added for the total number of random pulses received is so very small that the final result of selecting random numbers is so near the idealized result that there is substantially no difference for all practical purposes.

Random digit selecting systems can also be produced by slightly modifying or changing components. For example, it may possibly be advantageous to use a constant high-frequency generator in place of the random driving pulse generator, but to control the gate by a low-frequency random pulse source rather than a constant frequency source. The frequency of the pulses in each group would then be constant but the time interval of the group would vary at random.

Another modification may be to use random sources for both the driving pulse and the gating pulse. The pulse groups, then, would not only be for random frequency but also would last for random time intervals.

From the foregoing, it may be understood that various changes and modifications may be made in the structure and details of the invention without departing from the spirit and scope of the invention and I desire to be limited only by the scope of the appended claims.

I claim:

1. A device for random selection of digits by pure chance comprising pulse generating means developing an output of random frequency random amplitude pulses, means for passing and amplifying the random pulses from said generating means which exceed a predetermined minimum amplitude, a counter coupled to said last named means for counting the amplified random pulses and means in said coupling for cutting off the input of pulses to said counter at predetermined times whereby the digit on which said counter rests at pulse cut-off is a randomly selected digit.

2. A device for random selection of digits by pure chance comprising pulse generating means developing an output of random frequency random amplitude pulses, means for passing and amplifying the random pulses from said generating means which exceed a predetermined minimum amplitude, a standardizing circuit for standardizing said amplified random pulses into pulses of fixed amplitude and duration; means coupling said amplifying means through said standardizing circuit to a counter circuit adapted to count and display the standardized random pulses applied thereto, and a second pulse generator, a switching means controlled by the output of said second pulse generator and positioned in the coupling of said amplifier and said standardizing circuit for breaking the random pulses into groups, the digits displayed by the counter at the end of each group of random pulses determining the random digits selected.

3. A random digit generator comprising; a random pulse generator and first amplifier; means in the output of said first random pulse generator amplifier for passing pulse peaks of a voltage value greater by a predetermined value than the root-mean-square of the voltage fluctuation value of said random pulse generator first amplifier; a second pulse amplifier having its input coupled to the first said random pulse generator amplifier for amplifying said positive pulse peaks; a standardizing circuit for standardizing applied pulses in amplitude and duration; means coupling the output of said second pulse amplifier to said standardizing circuit; means for cutting off the second pulse amplifier at intervals; and a counter coupled to said pulse standardizing circuit for advancing over a sequence of numbers in accordance with the received standardized amplitude pulses, the number on which the counter rests at second pulse amplifier cut-off being a random selected number.

4. A random digit generator comprising; a random pulse generator; a pulse amplitude standardizing circuit and a counter comprising a plurality of binary counter control circuits, said binary counter control circuits controlling a circuit path to one of a plurality of digit contacts; means coupling said random pulse generator to said pulse amplitude standardizing circuit through a switching means and means coupling said pulse amplitude standardizing circuit to said counter; and a gating pulse generator having its output operatively connected to said switching means for interrupting the random pulses from said random pulse generator in accordance with the gating pulses whereby the circuit path selected by the binary counter control circuits at the time of interruption of the random pulses produces a random number on said counter.

5. A random digit generator as set forth in claim 4 wherein said switching means is a gating tube and an amplifier tube having their anodes connected in parallel and in the coupling to said pulse amplitude standardizing circuit, the grid of said amplifier tube being in the coupling to said random pulse generator and the grid of said gating tube being connected to the output of said gating pulse source such that pulses from the gating pulse generator control the conductive condition of said gating tube whereby during the conductive periods of said gating tube said amplifier tube is rendered inoperative thereby interrupting the passage of said random pulses.

6. A random digit generator as set forth in claim 4 wherein said pulse amplitude standardizing circuit is a one-cycle multivibrator that, when triggered by a random pulse, will produce a pulse of fixed amplitude and duration; and said binary counter control circuits each include a trigger circuit having two conditions of stability, one condition which results in energization of a corresponding double-position relay, the combination of energized and de-energized relays determining which one of a plurality of contacts, each representative of a digit, will be connected to a source of electrical energy.

7. A random digit generator comprising; a plurality of binary control circuits each including a trigger circuit of two tubes having two conditions of stability in each of which one tube is conductive and the other is cut off, one of said tubes in each trigger circuit being operative to control a double-position relay and the succeeding trigger circuit, the combination of energized and de-energized relays determining which one of a plurality of contacts, each representative of a digit, will be connected to a source of electrical energy, said trigger circuits each requiring the leading edge of a pulse to switch the condition of said trigger circuit tubes, two reversals of stability of each trigger circuit being required to reverse the tube condition of the next succeeding tigger circuit; means for generating random frequency pulses of random amplitude, means for passing and amplifying only those pulses exceeding a predetermined minimum amplitude, means to trigger the first trigger circuit by the amplified random pulses for positioning the relays at random; and means for interrupting said amplified random pulses at intervals whereby the electrical path through said relay contacts selected at each interruption of said amplified random pulse represents a random number.

8. A random digit generator as set forth in claim 7 wherein said means to trigger the first trigger circuit is a random pulse generator coupled through a pulse amplitude standardizing circuit to the tube cathodes of said first trigger circuit whereby the random pulses are standardized in amplitude and duration to insure a switch in tube condition in the first trigger circuit for random pulses of various amplitudes developed in said random pulse generator; and said means for interrupting said random pulses is a gating pulse generator operative to control a gating tube circuit in the coupling between said random pulse generator and said pulse amplitude standardizing circuit.

9. A random digit generator as set forth in claim 8 wherein said pulse amplitude standardizing circuit is a one-cycle multivibrator that produces a pulse of fixed amplitude and duration on said first trigger circuit tube cathodes for every random pulse received provided the spacing between random pulses is greater than the reset time of the one-cycle multivibrator, said random pulse generator having a biased crystal detector for passing only pulse peaks of amplitude considerably greater than the root-mean-square of the random pulses generated whereby every random pulse capable of passing said crystal biased detector will be effective to trigger said one-cycle multivibrator provided the spacing between random pulses is greater than the reset time of said one-cycle multivibrator.

10. A random digit generator as set forth in claim 9 wherein a cathode follower tube and a thyratron tube are employed in the control circuit between each trigger circuit and corresponding relay to control energization of the relay.

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