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PRODUCTION OF CURRENT OF RANDOM VARIATION

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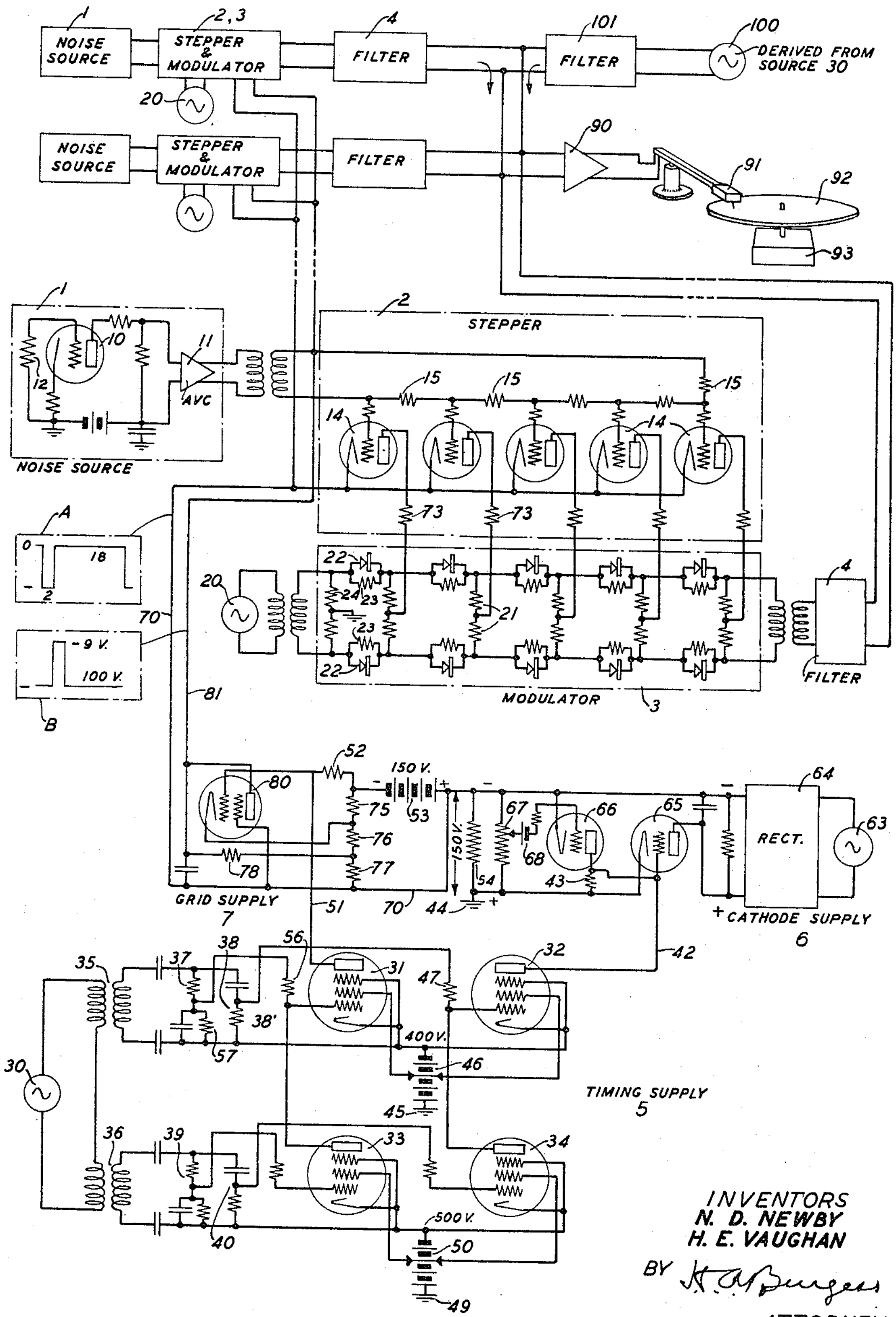

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PRODUCTION OF CURRENT OF RANDOM VARIATION

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The present invention relates to the production of currents having a stepped wave form and varying from one time interval to the next in a random manner or in a manner approaching random distribution with time.

One use to which such currents are put is in the coding of signals, as by the addition to the signals of key masking currents. The selection of random numbers or quantities by hand is a laborious process, involving such procedures as drawing numbers, shuffling cards, etc. so that great saving in time and labor is achieved by the present invention which operates automatically, continuously and indefinitely to produce currents having stepped amplitude of random or near-random variation.

The current thus produced can be used directly as a key wave for coding signals or can be recorded on a suitable record for future use.

In one type of signal system in which secrecy of transmission is desired, there are a number of separate channels used simultaneously, the transmission of all channels being effected on some sort of multiplex basis. In coding the signals, separate masking currents for the separate channels are desired, in one case eleven separate masking currents being required. The present invention can provide any number of separate masking currents at one time, each being unrelated to the others, and in the present disclosure it will be assumed that a number, such as eleven, masking waves are to be provided.

The invention depends for randomness of distribution of the current amplitudes upon the sampling at stated times of noise waves such as resistance noise or gaseous discharge tube noise, and the means for accomplishing the sampling involves a timing circuit and a set of trigger tubes or other response devices adjusted to have stepped response characteristics whereby the currents have stepped wave form.

A more complete understanding of the invention will be had from the following detailed description of one form of embodiment, which is illustrated by the schematic circuit diagram given in the single figure of the accompanying drawing.

In the drawing, each channel comprises a noise source 1, a stepper and modulator 2, 3 and a filter 4. One channel is illustrated in detail and two others are shown by blocks to indicate how any number of channels may be provided for. Common to all of the channels are a timing circuit 5, a cathode supply 6 and a grid supply 7, these supplies being for the steppers.

The noise source 1 can be of any suitable type capable of producing a sufficiently irregular and non-recurrent wave form such as resistance noise but is illustrated as comprising a hot cathode gas discharge tube 10, a type which produces noise waves of enough energy so that only moderate amplification is needed, indicated at 11. This amplifier should be provided with an automatic volume control for holding the average output constant. Tube 10 has its grid connected to its cathode through a high resistance 12 and is suitably energized.

The stepper 2 comprises a number of trigger tubes 14 (five being indicated). These tubes have grids or control electrodes which are periodically placed under control of the noise wave for an instant for sampling and are paralyzed the rest of the time. Depending on the instantaneous amplitude of the noise wave when sampled, none, one or more than one of the tubes 14 are triggered. This stepped response is secured by the potentiometer resistances 15 along which the grids are connected and which serve to subdivide the noise voltage from source 1 among the tubes 14. The connections are such that the full noise voltage is applied to the tube 14 at the left, and lesser fractions to each tube proceeding to the right. For ascending values of noise voltage, therefore, the first tube on the left breaks down, then the first two, first three, first four and finally all five for maximum amplitude of sampling used.

The modulator 3 comprises a means for converting the total current flow from tubes 14 as a group into corresponding magnitudes of a carrier wave supplied from source 20, the sources 20 having different frequencies for the separate channels to permit of separation of the stepped high frequency waves by filtering. Sources 20 may be vacuum tube oscillators or separate rotating generators mounted on a common shaft as is common in multiplex carrier telegraph practice. Each plate circuit of tubes 14 leads to the center of a resistance 21 and is returned to ground through one or more pairs of copper oxide varistor strings 22, with shunting resistors 23, 23, symmetrically arranged in both sides of the circuit to provide a balance. The ground connection is made at the center of resistor 24. If only the first tube 14 breaks down, the first pair of varistors 22 receives a modulating bias lowering their resistance a definite amount and permitting a definite increase in the amplitude of the carrier wave transmitted through to filter 4. Calling step zero the value of carrier current transmitted through the modulator with no tube 14 broken down (which can be either zero or some other chosen value), the carrier amplitude transmitted when the modulator is biased by discharge current from the first of the tubes 14 corresponds to step 1; the carrier amplitude transmitted when the modulator has applied to it the discharge current of the first two tubes 14 corresponds to step 2, etc.

The timing circuit 5 comprises a source of waves 30 having a constant frequency of 50 cycles per second. This is connected in parallel to the grids of tubes 31, 32 and 33, 34, through transformers 35, 36. During the 20 milliseconds elapsed during one complete period of the 50-cycle wave the tubes 31 and 32 are blocked except that they are made to transmit current for a brief period of 2.0 milliseconds once per cycle and at slightly different times, as will be further explained. By means of phase shifting circuits 37, 38 the time order in which the control grids of tubes 31 and 32 are thrown positive can be determined and the times are so chosen that tube 32 is first made conductive for 2.0 milliseconds and at the end of this 2.0-millisecond interval the tube 31 is rendered conductive for a similar interval. The ends of these short intervals are determined by the tubes 33, 34 and their phase shifting circuits 39, 40. Assuming that the 50-cycle wave is in a positive half-cycle and that at a certain point tube 32 is unblocked, space current will flow through this tube from its plate over lead 42, resistor 43, ground at 44, ground at 45, battery 46 to cathode. The effect of this current will be explained presently. After this space current has lasted 2 milliseconds, the timing is such that the tube 34 is unblocked sending current from its plate to the grid of tube 32, resistance 47, resistance 38′, through 400-volt battery 46 (in the reverse direction) to ground at 45, ground at 49, 500-volt battery 50 to cathode, and this current immediately blocks tube 32 by the large negative drop produced in resistances 47 and 38′ between the control grid and cathode. Tube 32 remains blocked until the 50-cycle wave again swings positive and reaches the same point in the cycle at which it previously began to transmit current. Tube **34** is blocked by the negative swing of the 50-cycle wave.

In similar manner, tube **31** at a certain point in the cycle, later than tube **32**, transmits current from its plate, lead **51**, resistor **52**, 150-volt battery **53** (in reverse direction) resistor **54** to ground at **44**, ground at **45** and 400-volt battery **46** to cathode. There is at this time a voltage of 150 volts existing across resistor **54** but the 400-volt battery **46** has sufficient voltage to send current through the circuit traced against the 300 volts bucking voltage at **53** and **54**. The effect of this current flow will be described presently. When tube **33** is unblocked 2 milliseconds later than tube **31**, current flows from its anode through resistor **56**, resistor **57**, 400-volt battery **46** (in reverse direction) to ground at **45**, ground at **49** and 500-volt battery **50** to cathode, thus cutting off tube **31** until the corresponding point of unblocking in the next cycle.

The stepper tubes **14**, when once triggered, remain conducting under control of the 150-volt cathode supply obtained from resistor **54**. This is obtained in turn from a regulated rectified supply starting with 60-cycle power circuit **63**, rectifier **64**, control tube **65**, and voltage detector tube **66**. Some of the rectified voltage is taken off resistor **67** through opposing battery **68** and applied to grid of tube **66** so that variations in the output rectified voltage are amplified by tube **66** and vary the voltage drop in resistor **43**, hence the voltage on the grid of control tube **65** to vary the series resistance in compensating manner and hold the terminal voltage across resistor **54** constant. This voltage regulating circuit is of known type and forms no part of the present invention. The space path for the tubes **14** of the stepper is traced from ground at **44**, through resistor **54** (the 150-volt supply), lead **70**, cathodes of tubes **14** of the stepper shown in detail, anodes of such of the tubes **14** as are broken down, resistor **73** to the midpoint of resistor **21** (and corresponding shunt resistors of the modulator), varistors and shunts **22**, **23** and **22**, **23** in pairs, resistor **24** to ground. In the steppers of the other channels the circuit is the same from resistor **54** over lead **70** to the cathodes, but the return is via the modulator **3** of the individual channel to ground. In order to restore all of the stepper tubes that are in transmitting condition, it is only necessary to interrupt the supply voltage from resistor **54** and this is done by the application of the current from the plate of tube **32**, as described, flowing through resistor **43** and setting up a blocking bias on the grid of control tube **65** which momentarily interrupts current flow through resistor **54** and deprives the tubes **14** in the steppers of plate voltage for a 2-millisecond interval. Out of each period of 20 milliseconds, therefore, plate voltage is applied to all of the tubes **14** for 18 milliseconds and is withdrawn for 2 milliseconds. This is indicated by the diagram A adjacent the cathode supply lead **70**.

The grid supply circuit **7** comprises a tube **80** having its cathode, grid and anode connected to points on the potentiometer formed of resistors **75**, **76** and **77** connected across the battery **53**. When no current is flowing through the tube **31** of the timing circuit, the control grid of tube **80** is about 9 volts negative toward the cathode due to drop of potential in resistor **75**, while the plate of the tube **80** is about 50 volts positive with respect to its cathode so that there is then applied to conductor **81** and to the grids of tubes **14** of all steppers a voltage in the neighborhood of −100 volts relative to lead **70** and the stepper tube cathodes.

Immediately after the timing circuit **5** restores the stepper tubes **14** by interrupting their space current supply voltage, tube **31**, as explained, blocks tube **80** for 2 milliseconds by sending current through grid resistor **52**. Conductor **81** then has applied to it only the small drop of potential existing across resistor **77** so that the difference of potential between conductors **70** and **81** is only just sufficient (e.g. −9 volts) to condition the tubes **14** for proper operation in response to the impressed noise voltage existing at that instant. The timing relation is indicated by the small diagram B referred to conductor **81**. This diagram, together with diagram A, indicates that the steppers are exposed to the noise waves at the beginning of each 18-millisecond interval and restored at the end of the interval.

The outputs of the modulators comprise carrier waves of different frequencies, each so shaped as to have its amplitude changed in steps of equal length and coincident timing but each wave having its stepped amplitude independently determined from its own noise wave and varying in random or near-random manner. These carrier waves can have frequencies spaced apart by 170-cycle intervals with the lowest frequency 595 cycles and the highest 2295 cycles, by way of example. The filters **4** have pass ranges such as to accommodate these frequencies and the outputs of all of the filters are shown as combined and leading through common amplifier **90** to the recording device **91** for simultaneously recording all of the carrier waves on record **92** which is shown on a suitable turntable driven from motor **93**. There is simultaneously recorded a standard frequency wave from source **100** which is put through filter **101**. This frequency may be 400 cycles and is useful for synchronizing or speed control of the record when the record is used for coding purposes. The standard frequency at **100** must be derived from source **30** by frequency multiplication or must be otherwise synchronized by source **30** so that when the pulses are taken from the record, the sampling may be synchronized with the recorded key. The disc record **92** is illustrative, it being understood that other known records such as magnetic, photographic and the like may be used alternatively.

For purposes of claiming, the modulator **3** may be considered as comprising a loss pad from which loss is removed in steps by the switching out of individual sections in response to discharge current through respective tubes **14**, and the recorder **91** may be considered as a suitable indicator of current transmitted from source **20** through the loss pad.

What is claimed is:

1. A circuit for producing currents having stepped amplitudes approximating random distribution in successive time intervals comprising a source of continuous frequency noise waves, a group of trigger tubes having input electrodes coupled to said source with graduated increase of coupling from tube to tube, a loss pad divided into sections, means controlled from the output electrodes of said trigger tubes for effectively switching out individual sections of said loss pad in response to discharge current through respective trigger tubes, a timing circuit for blocking the inputs of said trigger tubes except for an instant at the beginning of each time interval and for restoring all trigger tubes at the end of each time interval, a source of voltage, an indicator, and a circuit for connecting said loss pad in series between said source of voltage and said indicator.

2. A circuit for producing currents having stepped amplitudes approximating random distribution in successive time intervals comprising a source of fortuitous electrical noise vibrations, a group of electric discharge tubes having input and output electrodes, means to couple the input electrodes of said tubes to said source with graduated sensitivity to cause a varying number of said tubes to initiate discharge depending upon the instantaneous amplitude of the noise vibrations, a timing circuit for blocking the inputs of said tubes for all except the first part of each time interval, and to subject said tubes to the control of said noise vibrations for an instant in such first part of each time interval to cause a varying number of tubes to discharge, a resistance circuit the value of whose resistance is dependent upon the applied current, means to apply discharge current of said group of tubes to said resistance circuit to control its resistance in steps, and a source of voltage and utilizing device in series with said resistance circuit.

3. A circuit for producing currents having stepped amplitudes approximating random distribution in successive time intervals comprising a source of continuous spectrum noise waves, a group of trigger tubes, timing means for triggering certain of said tubes at the beginning of each time interval, means to cause the number of tubes triggered at any one instant to be dependent upon the instantaneous amplitude of the noise waves at that instant, a current dependent resistance circuit divided into sections connected in series, individual connections from said trigger tubes to sections of said resistance circuit for individually controlling the resistances of said sections, a source of indicating current, an indicator, and means connecting said resistance circuit in series between said latter source and indicator.

4. An impulse producer comprising a source of current, a varistor, and a load in series with each other, and a circuit for controlling said varistor in steps comprising

a plurality of trigger tubes, circuits for applying the discharge currents of different numbers of said trigger tubes to said varistor to control its loss in steps, a source of resistance noise, and a timing circuit for placing all of said tubes periodically under control of said resistance noise for a brief instant, said tubes having sensitivities varying in steps from tube to tube.

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