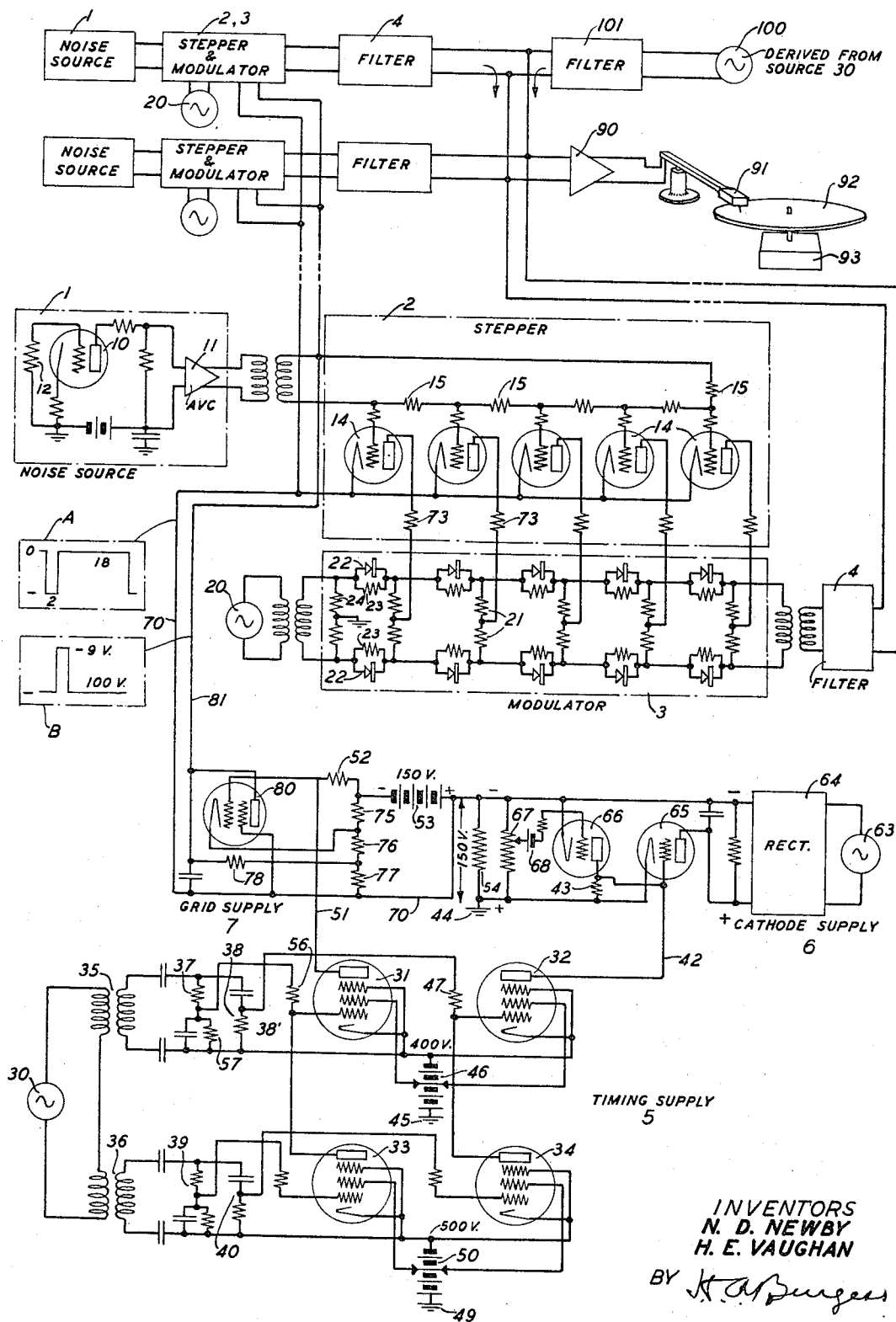


3,373,245

Filed Aug. 27, 1942



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3,373,245

PRODUCTION OF CURRENT OF RANDOM VARIATION

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Filed Aug. 27, 1942, Ser. No. 456,356

4 Claims. (Cl. 178—22)

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 instantane-

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ous 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 volt-

age 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,

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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

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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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