

March 5, 1968

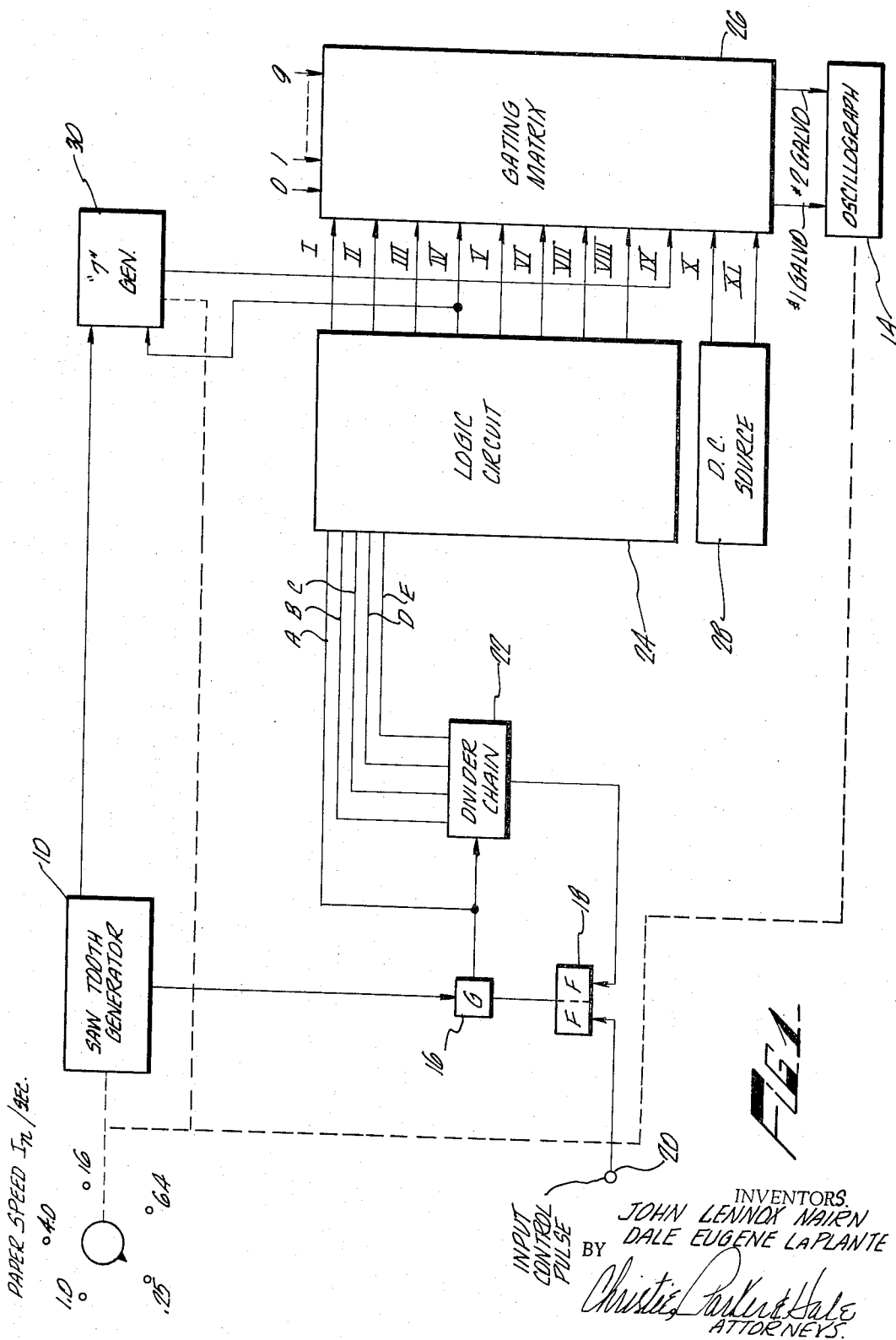
J. L. NAIRN ETAL

3,372,398

VARIABLE SPEED CHARACTER GENERATOR

Filed Jan. 21, 1966

4 Sheets-Sheet 1



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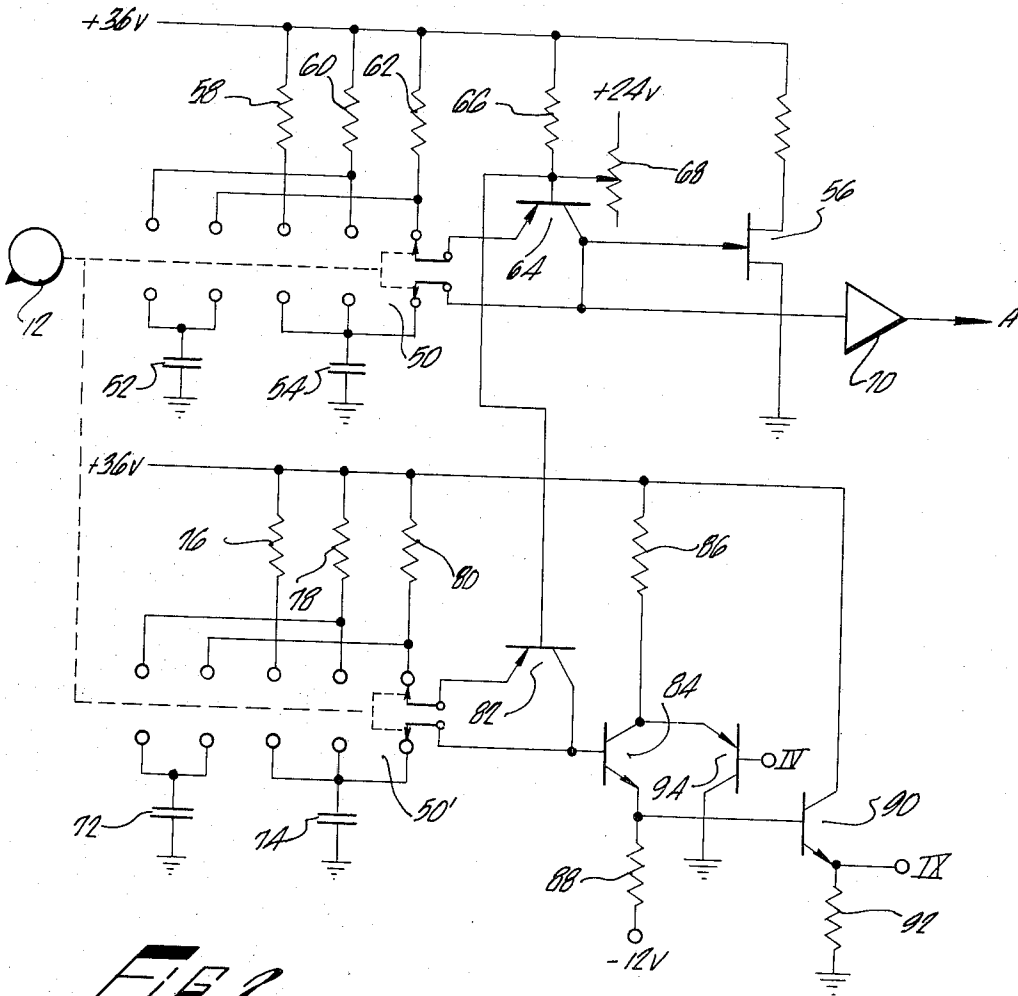


FIG. 2

$$\begin{aligned}
 I &= \bar{D}\bar{E} + \bar{D}\bar{E} + \bar{B}\bar{C}DE + BC\bar{D}\bar{E} \\
 II &= \bar{I} \\
 III &= \bar{A}\bar{B}\bar{C}DE + ABC\bar{D}\bar{E} \\
 IV &= \bar{D}\bar{E} + \bar{D}\bar{E} + \bar{A}\bar{B}\bar{C}DE + \bar{A}BC\bar{D}\bar{E} \\
 V &= \bar{A}BC\bar{D}\bar{E} + E \\
 VI &= \bar{A}\bar{B}\bar{C}DE + \bar{A}\bar{B}\bar{C}\bar{D}\bar{E} + D\bar{E}(A + \bar{B} + \bar{C}) \\
 VII &= \bar{D}\bar{E} + \bar{A}BC\bar{D}\bar{E} + \bar{A}\bar{B}\bar{C}DE + ABC\bar{D}\bar{E} \\
 VIII &= \bar{A}\bar{B}\bar{C}DE + \bar{A}\bar{B}\bar{C}\bar{D}\bar{E} + D\bar{E}(A + B + C) + D\bar{E}(A + \bar{B} + \bar{C})
 \end{aligned}$$

FIG. 5

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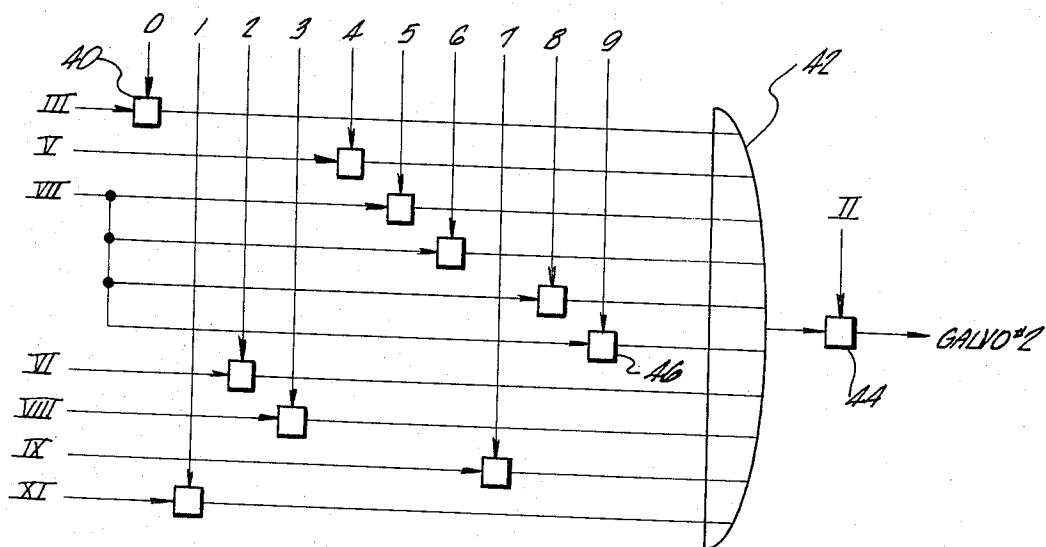
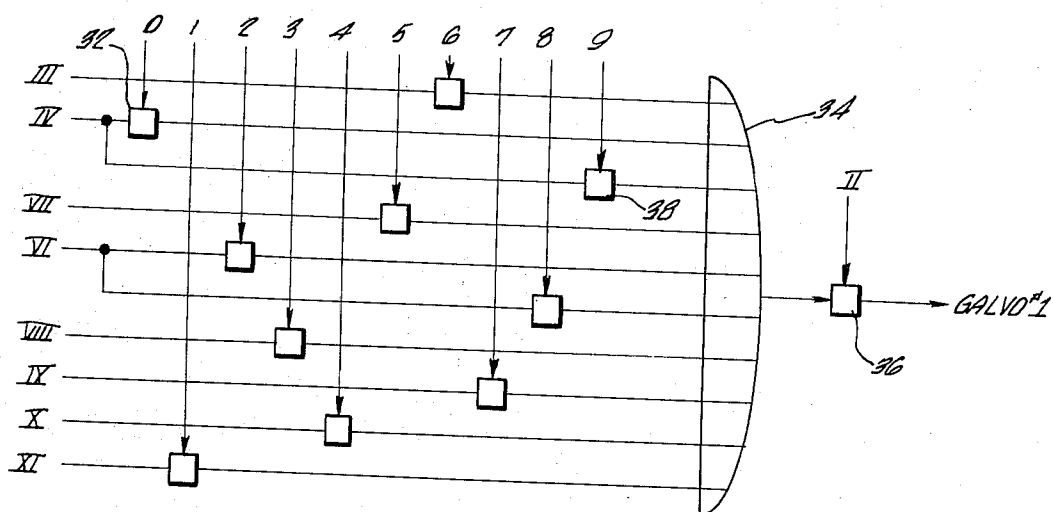


FIG. 3

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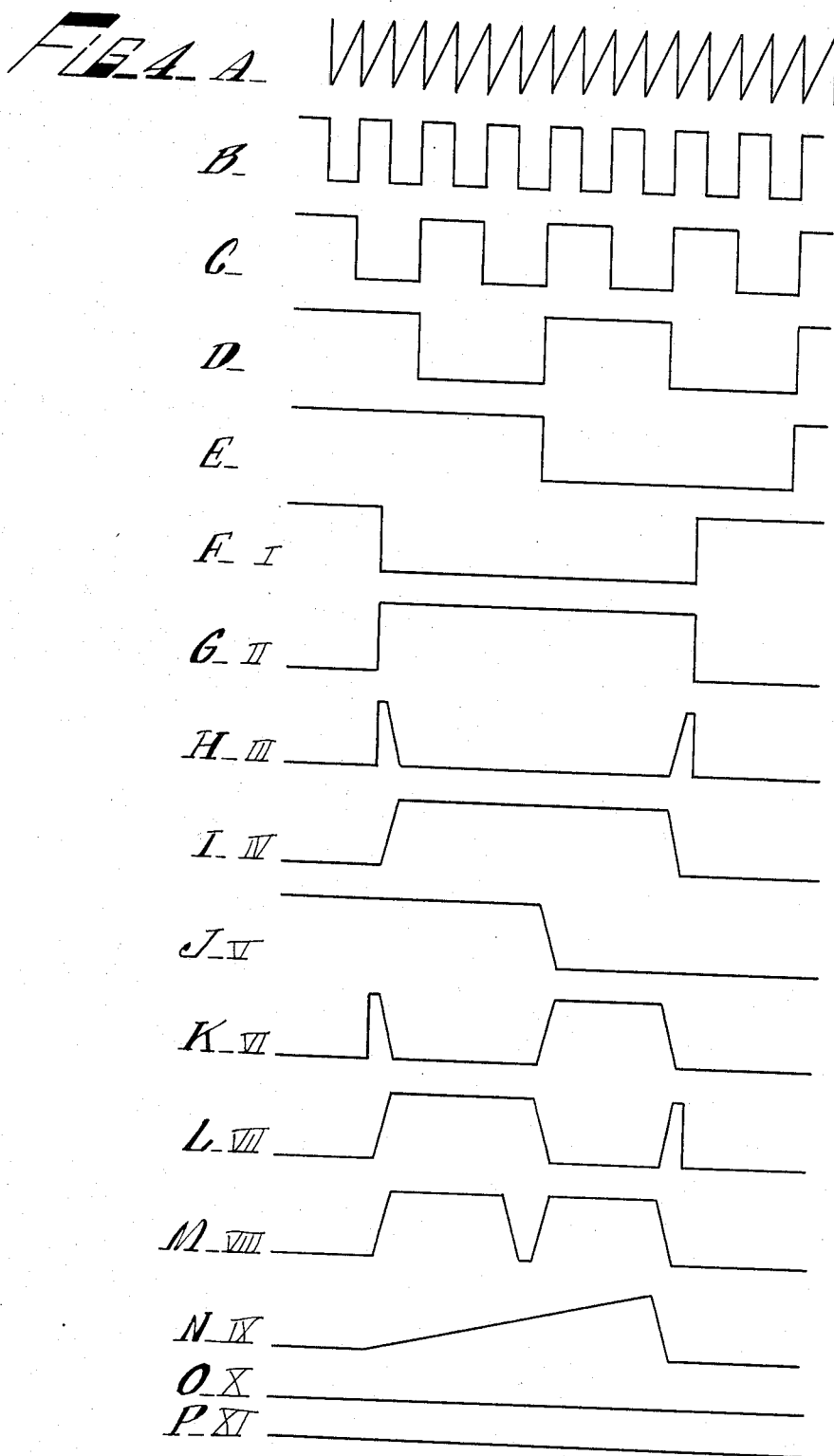
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VARIABLE SPEED CHARACTER GENERATOR

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3,372,398

VARIABLE SPEED CHARACTER GENERATOR
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8 Claims. (Cl. 346—33)

This invention relates to digital printout apparatus and, more particularly, is concerned with a waveform generator for controlling a pair of galvanometers to produce a visual printout of digital characters at different paper speeds.

It has heretofore been proposed to utilize a recording oscillograph as a means of "printing" numeric characters. By utilizing a pair of galvanometers deflected by suitable waveforms which are selected and combined on the basis of the value of the numerical character to be printed out, columns of arabic characters can be generated on the paper of the oscillograph. However, because of the complexity of the waveform generator, it has been difficult to make adjustments to change the character formation rate. Unless the character information rate can be adjusted, different paper speeds result in stretching or shortening of the numerals formed by the oscillograph. In addition, oscillographs having a wide range of paper speeds usually have their lamp intensity controlled by an automatic aperture so that at low writing speeds the intensity can be reduced, and at high paper speeds the intensity is increased. Thus at low speeds where the intensity is reduced, it is necessary to generate the characters more slowly with the galvanometers to properly form the image.

It has therefore been found desirable to provide a waveform generator for use with an oscillograph to generate and printout numerical characters which can be adjusted according to the writing speed of the paper. Such a waveform generator should provide waveforms that can be modified as required by a single simple adjustment for each one of a number of paper speeds.

In brief, the present invention provides for easy control of character formation rate by providing a waveform generator in which all waveforms necessary to control the deflection of the galvanometers to produce the numerical characters are generated from a single sawtooth wave generator in which the pulse repetition frequency is controlled by changing the slope of the sawtooth wave. The sawtooth generator is used to drive a divider from which rectangular waves at subharmonic frequencies of the sawtooth signal are derived. A logic circuit to which the rectangular waves and the sawtooth waves are applied produces a series of output waveforms which are combined by a gating circuit in response to digital input information to drive the oscillograph galvanometers. The significant feature of the present invention is that the slopes of the waveforms as well as the periods of the waveforms at the output of the logic circuit are simultaneously controlled by changing only the slope of the sawtooth wave generator output.

For a more complete understanding of the invention, reference should be made to the accompanying drawings wherein:

FIGURE 1 is a block diagram of the complete character generator system;

FIGURE 2 is a schematic diagram of the sawtooth generator and the character "7" generator;

FIGURE 3 is a schematic diagram of the gating matrix;

FIGURES 4A-4P show a series of waveforms used in explaining the operation of the present invention; and

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FIGURE 5 is a chart of "logic" equations for the logic circuit of FIGURE 1.

Referring to FIGURE 1, the numeral 10 indicates generally a sawtooth generator. The frequency of the sawtooth generator is controlled by a knob 12 which can be set to a number of positions corresponding to the different paper speeds used with an oscillograph, indicated generally at 14. If desired, the knob 12 may be also linked to the paper drive control (not shown) of the oscillograph 14 so that the same knob may be used to control both the sawtooth generator 10 and the paper drive speed of the oscillograph 14.

The output of the sawtooth generator is applied to a gate 16 controlled by a flip-flop 18. A character printout cycle is initiated by a pulse applied to an input terminal 20 connected to one side of the flip-flop 18. The control pulse sets the flip-flop 18 to one stable state in which the gate 16 is biased open. This permits a string of pulses from the sawtooth generator 10 to be applied to a divider chain 22. The divider chain 22 includes four flip-flop stages, each stage dividing the output frequency of the previous stage by a factor of two. The divider chain produces a series of rectangular output signals in which the repetition rate of each output signal is half that of the output signal of the previous stage.

The sawtooth signal at the output of the gate 16 as well as the rectangular waveforms derived from the divider chain 22 are applied to a logic circuit 24. The input signals are designated A through E, the corresponding waveforms being shown in FIGURES 4A-E.

The logic circuit 24 utilizes a plurality of "and" and "or" gates for combining the signals from the sawtooth generator 10 and the divider chain 22 to produce eight different output signals, indicated by I through VIII and shown in FIGURES 4F-M. The design of the gating logic of the circuit 24 is given by the logic equations of FIGURE 5. The implementation of such equations by "and" and "or" logic circuitry is well known in the art and further description of the circuit details is not considered necessary for a full understanding of the operation of the invention. By combining the input waveforms in the manner defined by the equations in the chart of FIGURE 5, the logic circuit 24 produces the output waveform I through VIII shown in FIGURES 4F-M. It will be noted that in each of these waveforms the output varies between two voltage levels with the slope of the transition between one voltage level and the other voltage level corresponding to the sloping edge of the sawtooth waveform of FIGURE 4A. Because of the more limited voltage range of the output waveforms III through VIII the sawtooth is somewhat clipped in logic circuit 24.

Each of the eight output signals from the logic circuit 24 is applied to a gating matrix 26 together with two different DC control levels, designated X and XI, derived from a DC source 28. These two levels are indicated by the waveforms X and XI in FIGURES 4O and 4P. The gating matrix 26 is controlled by ten inputs, designated 0 through 9, for selecting the numeric character to be printed. An input signal applied to one of these nine inputs activates the gating matrix 26 to combine preselected ones of the waveforms derived from the logic circuit 24 and applying the combined signals to two galvanometers of the recording oscillograph 14. Combinations of the waveforms of the logic circuit 24 and DC source 28 when applied to the two galvanometers can produce a trace on the paper corresponding to any selected one of the ten digital characters except for the number 7. A "7" generator circuit 30 generates an output waveform, as shown at IX in FIGURE 4N, by which

the character 7 is reproduced by the galvanometers of the oscillograph 14.

The gating matrix 26 is shown in more detail in FIGURE 3. For example, to generate the character 0, it will be seen that the gating matrix gates the waveform derived from the output IV of the logic circuit 24 by a gate 32 to the galvanometer No. 1 through an "or" circuit 34 and gate 36 to which is applied the waveform of output II of the logic circuit 24. At the same time, a gate 40 couples the waveform from the output III of the logic circuit 24 to galvanometer No. 2 through an "or" circuit 42 and a gate 44.

To generate the numeral 9, a gate 38 also couples the waveform at the output IV of the logic circuit 24 to the galvanometer No. 1 through the "or" circuit 34 and gate 36. Similarly, the character 9 gates the output VI of the logic circuit 24 through a gate 46 to the galvanometer No. 2 through the "or" circuit 42 and the gate 44. From an examination of FIGURE 5, the gating logic for generating each of the other arabic characters is apparent.

Referring to FIGURE 2, there is shown the details of the sawtooth generator 10 and the "7" generator 30. The selection knob 12 operates a five throw double pole switch 50. One pole of the switch 50 connects one of two capacitors 52 and 54 to the control electrode of a unijunction transistor 56. The other pole of the switch 50 selectively connects one of three resistors 58, 60 and 62 through the emitter-collector circuit of a transistor 64 to the control electrode of the unijunction 56. The base of the transistor 64 is connected to a positive potential through a relatively large fixed bias resistor 66, but the voltage can be controlled through a variable resistor 68. The transistor 64 acts as a constant current source for linearizing the charging of the selected one of the capacitors 52 or 54 through the selected one of the resistors 58, 60 and 62. When the selected capacitor charges to a predetermined level, the unijunction transistor fires, discharging the capacitor back to ground and starting the charging cycle over again. The switch 50 permits one of five different time constants to be selected to change the slope of the sawtooth wave generated by the oscillator. The output signal derived from the collector of the transistor 64 is amplified by a suitable amplifier 70 to drive the sawtooth output waveform A.

The "7" generator similarly includes a double pole five throw switch 50' which is ganged with the switch 50 to the control knob 12. The switch 50' similarly selects one of two capacitors 72 and 74 and one of three resistors 76, 78 and 80 to provide five different charging time constants. The values of the capacitors and resistors in the "7" generator are arranged to provide a time constant which is exactly ten times as long as the corresponding R-C time constant selected by the switch 50. The poles of the switch 50' are connected across the emitter-collector circuit of a transistor 82 whose base is connected to the base of the transistor 64 so that the charging rate of the two circuits can be adjusted by the common adjustable resistor 68. The transistor 82 acts as a constant current source for the charging of the selected capacitors 72 and 74 through the selected one of the resistors 76-80.

The collector of the transistor 82 is connected to the base of a transistor 84 whose collector is connected through a resistor 86 to a positive supply voltage and whose emitter is connected through a resistor 88 to a negative supply voltage. The output derived across the emitter resistor 88 is coupled to an emitter follower stage provided by a transistor 90 and load resistor 92. A switching transistor 94 connected between the collector of the transistor 84 and ground is controlled by the signal derived from the output IV of the logic circuit 24. At the trailing edge of the signal applied to the base of the transistor 94, the charging capacitors are rapidly discharged through the transistor 84 and transistor 94 back to the level of the voltage at the base of the transistor 94. Thus the trailing edge of the output signal across the

resistor 88 follows the slope of the trailing edge of the waveform applied to the base of the transistor 94, providing the desired "7" voltage waveform at the output from the emitter follower 90.

What is claimed is:

1. A waveform generator comprising a sawtooth generator, means for selectively changing the slope and frequency of the sawtooth generator output, a rectangular wave generator for simultaneously generating a plurality of rectangular waves whose repetition frequencies are harmonic of the fundamental frequency of an input synchronous signal, means for deriving a synchronizing signal for the rectangular wave generator from the output of the sawtooth generator, whereby the outputs of the rectangular wave generator change in frequency with changes in frequency of the sawtooth generator, and means coupled to the output of the sawtooth generator and the outputs of the rectangular wave generator combining selected portions of the rectangular waves and the sawtooth wave.

2. Apparatus as defined in claim 1 wherein said combining means forms rectangular wave signals in which the slope of the leading and trailing edges conform to the slope of the sawtooth generator.

3. Apparatus as defined in claim 2 wherein the combining means includes a plurality of logical "or" and "and" circuits connected in a logic network.

4. Apparatus as defined in claim 1 wherein the rectangular wave generator is a flip-flop divider circuit.

5. Apparatus as defined in claim 1 further including a second sawtooth generator having a period substantially longer than the said first mentioned sawtooth generator, and means for changing the slope of the sawtooth wave in direct proportion to the change in slope of the output of the first sawtooth generator.

6. In a digital oscillograph in which the drive speed of the paper may be set at any one of a number of rates, a waveform generator for generating a plurality of waveforms in which the time scale can change with changes in speed of the paper to maintain fixed vertical size and shape of each character, comprising a first sawtooth generator, means for changing the frequency of the sawtooth generator with changes in the paper drive speed, a circuit generating a plurality of rectangular wave output signals having repetition frequencies that are multiples of the repetitive frequency of an input signal, means for driving the rectangular wave circuit in response to the output of the sawtooth generator, and means for combining portions of the outputs from the rectangular wave circuit and the sawtooth generator to generate a plurality of output signals having waveforms in which the slope of all leading and trailing edges are fixed by the slope of the sawtooth generator output.

7. Apparatus as defined in claim 6 further including a second sawtooth generator having a period substantially longer than the said first mentioned sawtooth generator, and means for changing the slope of the sawtooth wave in direct proportion to the change in slope of the output of the first sawtooth generator.

8. Apparatus as defined in claim 6 including means responsive to the output of the first sawtooth generator for fixing the slope of the trailing edge of the sawtooth wave output of the second generator to be equal to the slope of the leading edge of the sawtooth wave output of the first generator.

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