

Sept. 22, 1964

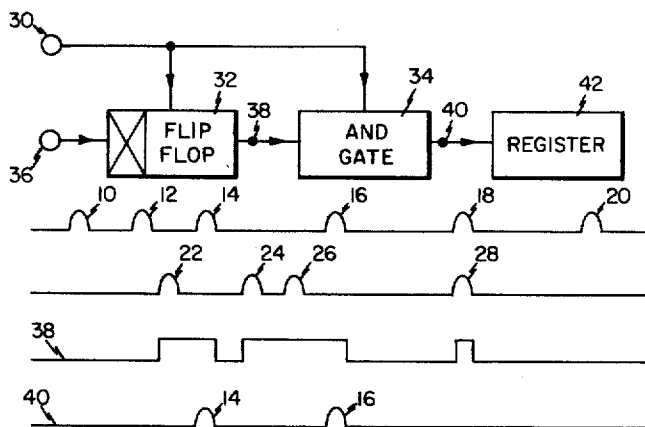
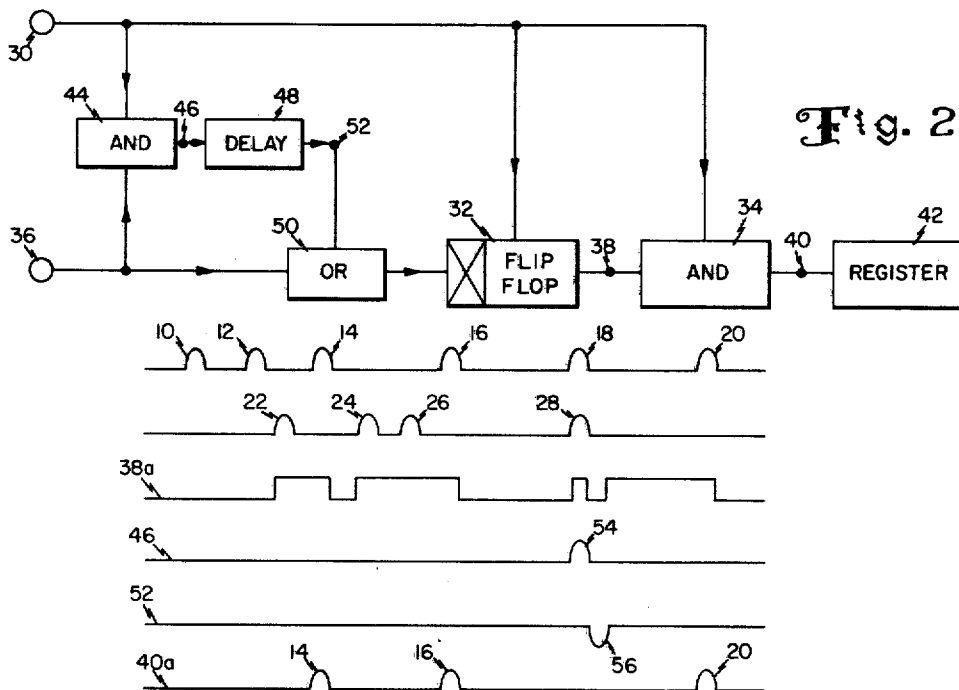
R. P. EINSEL ET AL

3,150,352

TIME SYNCHRONIZATION OF RANDOM ELECTRICAL SIGNALS

Filed Oct. 25, 1957

3 Sheets-Sheet 1



01077
01078
01079-P
01080
01081-P
01082
01083
01084
01085
01086

Fig. 6

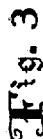
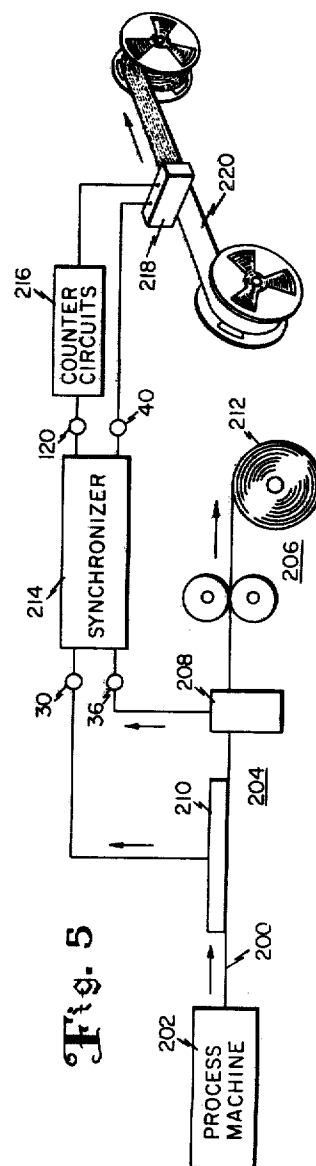
INVENTORS
ROBERT P. EINSEL
PHILIP SPERGER

by *Anthony D. Cannano*

3,150,352

Filed Oct. 25, 1957

3 Sheets-Sheet 2



ROBERT P. EINSEL
PHILIP SPERGER

by Anthony D. Cannaneo

Sept. 22, 1964

R. P. EINSEL ET AL

3,150,352

TIME SYNCHRONIZATION OF RANDOM ELECTRICAL SIGNALS

Filed Oct. 25, 1957

3 Sheets-Sheet 3

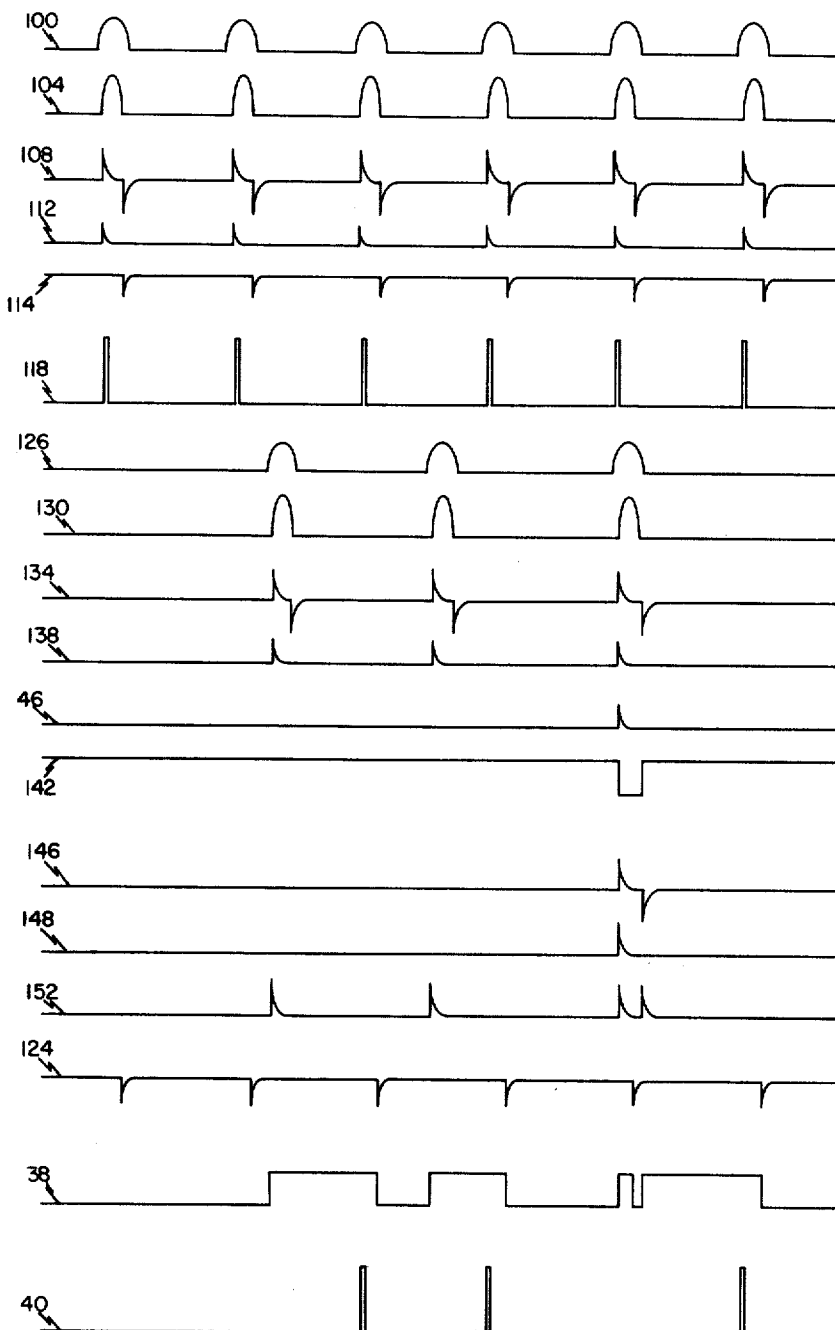


Fig. 4

INVENTORS

ROBERT P. EINSEL
PHILIP SPERGER

By Anthony D. Cunniff

1

2

3,150,352

TIME SYNCHRONIZATION OF RANDOM ELECTRICAL SIGNALS

Robert P. Einsel and Philip Spergel, Columbus, Ohio,
assignors to Industrial Nucleonics Corporation, a corporation of Ohio

Filed Oct. 25, 1957, Ser. No. 692,490

5 Claims. (Cl. 340—172.5)

This invention relates to a method and means for time synchronization of mutually contemporaneous successions of events, and more specifically it relates to an electronic system for identification of variable time intervals wherein random events have occurred.

In data accumulation systems, there are many and various known devices whereby equal time intervals coincident with random events can be identified, tallied, and/or classified by automatic means. However, there is a need for a method and means whereby such automatic manipulations can be positively and reliably consummated when the length of said time intervals is subject to variation in an unpredictable manner, as will be set forth by exemplification hereinafter in consideration of an industrial production quality indicating and recording system.

In accordance with a preferred embodiment of this invention, it is proposed that an electrical pulse be derived to mark each division between the end of one variable time interval in a series thereof and the beginning of the succeeding interval. It is further proposed that a similar pulse be derived to indicate the occurrence of each random event. The time interval marking pulses are fed to a registration device through a transmission path having a gate therein which is opened by the occurrence of a random pulse and closed immediately upon the passage of a marking pulse therethrough. That is to say; if during a particular time interval a random pulse occurs, the gate is opened thereby, so that the next interval separation marking pulse may pass to the registration device, whereupon the gate is reclosed. Since the gate remains closed except on the occurrence of a random pulse, a marker pulse indicating the end of a variable time interval is not registered unless it has been preceded during that interval by one or more random events.

The efficacy of the above rather simple expedient is not absolute, however, in that a random event may not be registered if it happens to occur simultaneously with the marker of an interval, due to interference between the action of the random pulse to open the gate and that of the marker to close the same. In order to eliminate the possibility of such malfunction, a preferred embodiment of the present invention further provides circuitry responsive to coincidence between a random pulse and a marker pulse for generating a carry-over pulse of relatively long duration. The trailing edge of the carry-over pulse is utilized to positively open the gate after the coincident pulse has expired, so that the marker pulse succeeding the coincident one may pass through the gate to register the coincident random event whose occurrence would otherwise have been missed.

It is an object of this invention to provide a method and means for time synchronization of contemporaneous successions of events.

It is a further object to provide electronic apparatus for time synchronization of contemporaneous successions of events signalizable by electrical means.

It is a still further object to provide a method and means for identification of variable time intervals wherein one or more random events have occurred.

It is another object to provide automatic means whereby time intervals of unpredictably variable length can be identified, tallied, and/or classified according to the oc-

currence or non-occurrence of one or more random events in a given interval.

It is also an object to provide an industrial production quality indicating and recording system whereby incremental quantities of material produced by high speed continuous processing equipment may be identified, tallied, and/or classified according to the presence or absence of a characteristic of interest therein.

Other objects and advantages of the invention will become apparent in the following detailed description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagram of a basic electronic identification apparatus in accordance with this invention, associated with graphic illustrations of waveforms involved therein.

FIG. 2 is a simplified diagram of an improvement on the apparatus of FIG. 1 and waveforms associated therewith.

FIG. 3 is a complete schematic diagram of a preferred embodiment of the apparatus outlined in FIG. 2.

FIG. 4 is a complete waveform and timing diagram illustrating the functions of the apparatus of FIG. 3.

FIG. 5 is a showing of the delivery section of a continuous industrial process line associated with an inspection and data accumulation system incorporating the invention.

FIG. 6 illustrates the presentation of data provided by the system of FIG. 5.

Referring to FIG. 1, the divisions between a succession of variable time intervals are indicated by a series of marker pulses 10-20. The contemporaneous occurrence of a succession of random events is similarly indicated by the pulses 22-28, shown plotted on the same time base as pulses 10-20.

Marker pulses 10-20 are impressed on terminal 30, providing an input to a flip-flop 32 and to an AND gate 34. Random pulses 22-28 are impressed on terminal 36, and provide a second input to flip-flop 32. The output 38 of the flip-flop 32 provides a second input to the AND gate 34. The output 40 of the AND gate is connected to a register 42. The signal output of the flip-flop 32 and the output 40 of AND gate 34 in response to the two successions of pulses 10-20 and 22-28 are also plotted on an identical time base therewith.

It is seen that the first two marker pulses 10 and 12 do not appear in the output 40 since they are blocked by the AND gate 34. In the time interval between marker pulses 12 and 14, however, the occurrence of a random event is signalled by pulse 22, whose leading edge "turns on" flip-flop 32 as is indicated in the plot 38 of the flip-flop output. Hence the next marker pulse 14 to arrive is able to pass the AND gate 34 and to appear in the output 40 of the same so as to trigger the register device 42. Referring again to output 38 of flip-flop 32, it is seen that the trailing edge of pulse 14 turns off flip-flop 32, so that the AND gate is re-closed after passage of pulse 14 therethrough. Similarly, random pulses 24 and 26 arrive in the interval between marker pulses 14 and 16. Since flip-flop 32 is again turned on by the leading edge of pulse 24, as is shown by the graph of output 38, marker pulse 16 is passed to register 42 to indicate an interval containing a random event, as is shown by the graph of output 40. This result is obtained in accordance with the objects of the invention, since what is desired to be known is whether or not a given time interval coincides with the occurrence of at least one random event. The fact that more than one event, or any number of additional events in excess of one, may also occur during this interval is quite immaterial for the purpose of the invention, as will appear hereinafter.

The possibility of missing the occurrence of a random event by the simple apparatus of FIG. 1 is apparent in the example shown of random pulse 28 which appears

coincidentally with marker pulse 28. Referring to the graph of the output 38 of flip-flop 32, it is seen that the flip-flop is turned on by the leading edge of random pulse 28 and turned off again by the trailing edge of marker pulse 18. As a result neither of marker pulses 18 or 20 passes AND gate 34 to register the occurrence of the random event signalled by pulse 28.

To eliminate the above exemplified difficulty, the preferred embodiment of the invention depicted in FIG. 2 further provides an AND gate 44 responsive to time coincidence between a marker pulse at terminal 30 and a random pulse at terminal 36. Such coincidence produces a trigger pulse at the output 46 of AND gate 44. The trigger pulse is propagated through a delay circuit 48 and delivered to an OR gate 50 interposed between the flip-flop 32 and the random pulse input 36 of FIG. 1. Thus the flip-flop 32 may be turned on by either a random pulse appearing at terminal 36 as in the device of FIG. 1 or by a delayed coincidence pulse on line 52.

From the associated waveform and timing diagram depicted in FIG. 2, it is seen that the device thereof functions in a manner identical with that of the device of FIG. 1 up to the point where the random pulse 28 arrives coincidentally with marker pulse 18. At this instant the AND circuit 44 passes trigger pulse 54 to the delay device 48. As in the operation sequence above described in connection with FIG. 1, the flip-flop 32 is again turned on by the leading edge of random pulse 28 and turned off again by the trailing edge of marker pulse 18. Shortly thereafter, however, a delayed pulse 56 appears on line 52. Thereby the flip-flop is again turned on to await the arrival of the next marker pulse 20, which is thus enabled to pass the AND gate 34 and register the occurrence of random pulse 28. The characteristics of the apparatus in FIG. 2 are such that the time intervals between marker pulses are sharply separated by a point on the leading edges of the marker pulses. Accordingly random pulse 28 is properly classified as belonging to the interval separated by marker pulses 18 and 20.

It must be understood that the particular electronic apparatus depicted in FIG. 1 and FIG. 2 is merely illustrative to demonstrate the operation of specific means whereby the identification method of this invention may be carried out. Basically the procedure is to generate a marker pulse at the end of each time interval, to generate a signal pulse upon the occurrence of each random event, to feed the marker pulses into a transmission path, to block said path following the occurrence of a marker pulse, to unblock said path upon the occurrence of a signal pulse, and to register those marker pulses which are transmitted through said path. FIG. 2 further illustrates means for performing additional precautionary steps in the procedure so as to preclude missing a random event when the blocking and unblocking actions are called for at the same time. The essential precautionary steps are to generate a record of each simultaneous occurrence of a marker pulse and a signal pulse, to store said record until the next blocking action has been terminated, to generate a record pulse from the stored record, and to unblock the transmission path upon the occurrence of the record pulse.

FIG. 3 is a complete diagrammatic representation of one preferred embodiment of the present invention in accordance with the principles illustrated by the simplified apparatus of FIG. 2. A complete waveform and timing diagram therefor is shown in FIG. 4. Marker pulses 100 admitted to terminal 30 are amplified and shaped by amplifier 102. The amplified pulse 104 is differentiated by circuit 106. The differentiated pulse 108 is passed through a dual clipper network 110 to separate positive 112 and negative-going 114 portions thereof. The positive-going pulse 112 is used to trigger a reset generator or blocking oscillator at 116 which provides a high, narrow pulse 118 which is delivered to an output terminal 120 and is also applied to one input 122 of the AND gate

34. The negative-going pulse 114 is applied to the cut-off input 124 of the flip-flop 32.

The random signal pulses 126 admitted to terminal 36 are amplified and shaped by amplifier 128. The amplified pulse 130 is differentiated by circuit 132, and the differentiated pulse 134 is clipped at 136 to select the positive-going portion 138 thereof, which is passed by the OR gate 50 to turn on the flip-flop 32. When the flip-flop is turned on, its output 38 provides the enabling input to AND gate 34 which permits the same to pass the reset generator pulse 118 to output terminal 40.

The coincidence circuit comprises the AND gate 44 which permits pulse 138 to appear on line 46 when the AND gate 44 is enabled by a pulse 104 appearing thereat. The delay circuit comprises a one-shot multivibrator 140 which generates a square wave pulse 142 when triggered by a pulse at its input 46. Multivibrator 140 is designed to deliver a pulse 142 whose duration is somewhat longer than that of pulse 104 provided by marker pulse amplifier 102. Pulse 142 is differentiated by circuit 144. The negative-going portion of the differentiated pulse 146 which corresponds to the leading edge of pulse 142 is discarded, whereas the positive-going portion 148 which corresponds to the trailing edge thereof is passed by a clipper 150 to the OR gate 50 via which it may turn on flip-flop 32 in the same manner as pulse 138.

In the diagram of FIG. 4, pulse trains 100, 104, 108, 112, 114, 118, 126, 130, 134 and 138 are so numbered in accordance with corresponding single waveforms shown on FIG. 3. Numeral 46 indicates the coincidence pulse train on line 46 of FIG. 3. Pulse trains 142, 146 and 148 correspond to single waveforms so numbered in FIG. 3. At 152 is the pulse train appearing at the output of the OR gate 50 which is applied to the enabling input of the flip-flop 32. Pulse train 124 is merely a repetition of train 114 as applied to the disabling input 124 of the flip-flop. Train 38 depicts the signals on flip-flop output 38 in response to input trains 152 and 124. Train 40 comprises the interval identification signal train on output terminal 40, which may be compared with the interval marker signal train 118 appearing at output terminal 120.

FIG. 5 depicts an illustrative application of the present invention to an industrial production quality indicating system. Herein a semi-finished or finished product material 200 is shown issuing in a continuous length from a processing machine 202. After passing through automatic inspection apparatus 204 the material is delivered to accumulation means 206 where the material is prepared for shipment or transport to further processing apparatus. The inspection apparatus comprises an instrument 208 responsive to the presence of a property of interest in the material 200 passing therethrough. There may also be a device 210 associated with inspection apparatus 204 which is responsive to the passage of unit lengths of material 200 thereby. It is desired that each unit length be identified, tallied, and/or classified according to the presence or absence therein of the material property to which instrument 208 is responsive.

Inasmuch as at least the delivery section herein shown of the process line may run at different speeds or varying speed, the time intervals marking the passage of unit lengths of material 200 past the inspection station are also subject to variation. The detection of an irregularity by instrument 208 is expected to occur in completely random fashion.

For a still more specific example, it may be assumed that the apparatus of FIG. 5 comprises the delivery section of a tin plate line. Formerly it was customary to shear the strip 200 into sheets which were individually inspected. However, since electroplating lines are being operated at increasingly higher speeds, this expedient is becoming less and less the practice, since the shears and sheet sorters can no longer keep pace with the rate of production of strip. Accordingly the strip is coiled as at 212 for delivery to other apparatus for shearing and classification.

Continuing with this example, it is further assumed that the property of interest is the presence of pinholes in the strip. In accordance with the objects of the invention, it is desired to identify any unit length of tin plated strip which contains one or more pinholes. Such a unit length is of course clearly defective for a purpose such as the manufacture of tin cans, regardless of the particular number of pinholes therein. Pinholes can be detected with conventional photoelectric apparatus 208, which produces an electrical pulse when a portion of strip containing a pinhole passes therethrough. Device 210 may be no more than a circuit including a simple interrupter switch operated by a cam driven through the agency of a roll in positive tractive engagement with the strip, although it may be preferable to utilize an electronic method, such as is described in U.S. Patent No. 2,466,251, issued April 5, 1949, to Philip W. Martin, in the case of a magnetizable strip traveling at high speed. Electrical pulses generated by devices 208 and 210 are fed into device 214, which may be termed a synchronizer, and which is exemplified by the system shown in FIG. 3. Thus pulses from the length measuring device 210 are delivered to input terminal 30 of the synchronizer at variable time intervals depending on the speed of the strip 200, and random pulses indicating the occurrence of pinholes therein are delivered to input terminal 36.

In one system whereby device 214 may be utilized, the pulse output thereof on terminal 120 indicating passage of successive lengths of material may be applied to a simple sequential counter chain 216. The counter 216 is adapted to deliver digitized numeral pulses to a recording head 218 which records sequential coded numerals on a strip of magnetic tape 220 passing therethrough. An auxiliary channel of the recording head connected to output terminal 40 records the presence or absence of a pinhole simultaneously with the numbering of a unit length of material 200. The use of electronic pulse circuitry and a fast recording medium such as magnetic tape permits the design of a production indicating system capable of extremely high speed operation and excellent accuracy.

The record provided on tape 220 may be utilized for later quality analysis of strip production in a number of different ways. For example, the tape may be fed into an automatic printer to make a printed record such as is shown in FIG. 6, whereon a particular unit length of material such as No. 1079 or No. 1081 may be classified as containing a pinhole by the suffix P following the number thereof. A pertinent portion of such a printed record may accompany the shipment of each coil of tin plate as a guide to the grading, pricing, and eventual utilization thereof.

While the identification system of this invention is illustrated and described in connection with specific apparatus whereby the objects of the invention are clearly accomplished, such specific apparatus is so illustrated and described by way of example only, and should not be considered as being in any way restrictive to the definition of the invention, inasmuch as a great many changes and modifications thereto in other and outwardly quite different apparatus can be made without departing from the spirit and scope thereof as is set forth in the appended claims.

What is claimed is:

1. In a system for accumulating data concerning a succession of variable time intervals accompanied by a succession of random events, electronic apparatus for identifying those intervals which are characterized by the occurrence therein of a random event, which comprises: means for generating an electrical marker pulse at the end of each of said time intervals, means for generating an electrical signal pulse upon the occurrence of each of

said random events, a transmission path for said marker pulses, means for blocking said path immediately following the transmission therethrough of a marker pulse, means for unblocking said path upon the occurrence of a signal pulse, means for generating a record of each simultaneous occurrence of a marker pulse and a signal pulse, means for storing said record until the next blocking action has been terminated, means operative after said termination of said blocking action for generating a record pulse from said stored record, means for unblocking said transmission path upon the occurrence of a record pulse, and means for registering marker pulses transmitted through said path.

2. Apparatus as in claim 1 wherein said blocking means and said unblocking means comprise a gating circuit responsive to a control signal, a flip-flop circuit having a first stable state activated by a signal pulse and a second stable state activated by passage of a marker pulse, and wherein said control signal is provided by only one of said stable states.

3. Apparatus as in claim 2 wherein said record generating means comprises a coincidence circuit responsive to simultaneous occurrence of a marker pulse and a signal pulse for producing a trigger pulse, wherein said storing means comprises a one-shot multivibrator for producing a carry-over pulse having a time duration not less than that of said marker pulse, wherein said record pulse generating means comprises a circuit for differentiating said carry-over pulse and a circuit for rejecting the leading portion of the differentiated pulse, and wherein said means for unblocking said transmission path upon the occurrence of a record pulse comprises an OR gate for passing the trailing portion of said differentiated pulse to said flip-flop so as to activate said first stable state thereof.

4. In an apparatus for inspecting a continuous length of material for defects occurrent at random therein, means for conveying said material lengthwise past an inspection station, inspection means located at said inspection station and responsive to the presence of said defects for generating an electrical signal pulse signaling the passage of each of said defects, means responsive to the movement of said material for generating an electrical marker pulse each time a selected length of said material has passed said inspection station, a transmission path for said marker pulses, means for blocking said path immediately following the transmission therethrough of a marker pulse, means for unblocking said path upon the occurrence of a signal pulse, means for generating a record of each simultaneous occurrence of a marker pulse and a signal pulse, means for storing said record until the next blocking action has been terminated, means operative after said termination of said blocking action for generating a record pulse from said stored record, means for unblocking said transmission path upon the occurrence of a record pulse, and means for registering marker pulses transmitted through said path.

5. Apparatus as in claim 4 including means responsive to said generated marker pulses for providing sequential count manifestations thereof for identifying each of said selected lengths of material, and means responsive to said marker pulses transmitted through said path for indicating those of said identified lengths which contain one or more of said defects.

References Cited in the file of this patent

UNITED STATES PATENTS

2,700,696	Barker	Jan. 25, 1955
2,740,090	Dionne	Mar. 27, 1956
2,793,344	Reynolds	May 21, 1957
2,807,003	Alrich	Sept. 15, 1957