A system for providing indication of both the quality of individual manufactured articles and the quality of the process for manufacturing the same. Circuit means are included for sensing article characteristics and making determinations (1) whether each article exhibits all requisite characteristics, (2) whether each article has fewer than a predetermined number of requisite characteristics, and (3) whether each article is a predetermined succession exhibits less than the requisite number of characteristics. Circuit means are provided for indicating the determinations made and for conveying indications of determinations (1) to article control apparatus and indications of determinations (2) and (3) to process control apparatus.

11 Claims, 4 Drawing Figures
QUALITY CONTROL SYSTEM

FIELD OF THE INVENTION

This invention pertains to systems for use in manufacturing articles and more particularly to improved quality control systems.

BACKGROUND OF THE INVENTION

In the automated manufacture of articles having a plurality of requisite characteristics, it is customary to provide a quality control system adapted to determine, by photoelectric, magnetic or like article monitoring means, those manufactured articles not meeting predetermined standards of acceptability. Determinations of non-acceptability are customarily conveyed to indicators or to associated apparatus adapted to delete non-acceptable articles from the assembly line.

Such quality control systems clearly provide assurance against the delivery of non-acceptable articles to consumers, but have essentially no other capabilities. Thus, despite the vast information such quality control systems may collect in respect of manufactured articles, the systems find use only in article rejection as discussed, and, accordingly are generally employed in combination with other independent manufacturing systems, e.g., systems which provide for process control.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a composite quality control and article manufacturing control system.

It is a more particular object of the present invention to provide a quality control system providing output information in respect of both article rejection and manufacturing process rejection.

In brief summary thereof, the system of the present invention incorporates first circuit means for detecting requisite characteristics of each manufactured article and providing output signals where detected characteristics have magnitudes exceeding a predetermined magnitude, signal counters for providing selective summations of the output signals of the first circuit means, second circuit means responsive to said counters and providing an output signal where one or more counters has counted to less than a first predetermined number and third circuit means responsive to said counters and providing an output signal where all counters, taken collectively, have counted to less than a second predetermined number. The system of the invention may further include fourth circuit means, responsive to said second circuit means and providing an output signal where the second circuit means provides output signals in respect of a predetermined succession of articles.

The system may further include article reject apparatus responsive to the first circuit means output signals and process reject apparatus responsive to the third and fourth means output signals.

The foregoing and other objects and features of the invention will be evident from the following detailed description thereof taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagrammatic illustration of the system of the invention.

FIG. 2 is a plan view of a typical article of manufacture, the quality of which and the qualities of the manufacturing process of which, are determinable by the system of FIG. 1.

FIG. 3 is a cross-sectional view of the article of FIG. 2 taken along the lines II—II of FIG. 2.

FIG. 4 is a schematic drawing of preferred embodiments of article monitors 80 and 110 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, the system of the invention includes a plurality of article characteristic sensing units 10, 20, 30, 40 and 50, each having the structure indicated for channel 10, which provide output signals on lines 11, 21, 31, 41 and 51, respectively. These units are each adapted, by arranging elements thereof in sensing position relative to the article conveyor, to detect a selective plurality of article characteristics as the article is conveyed through such sensing position. The conveying of an article to such position is detected by entry detecting unit 60 which accordingly provides an output signal on line 61. The conveying of the article beyond such position is detected by exit detecting unit 70 which accordingly provides an output signal on line 71.

The output lines of the characteristic sensing units terminate individually in resettable counters 12, 22, 32, 42 and 52, entry detecting unit output line 61 being connected to each of the counters for resetting the same to zero count before each article enters the sensing position. The counters are conventional binary counters, the binary coded decimal (BCD) output signals of which are applied to output conductors 13, 23, 33, 43 and 53, each comprised of a plurality of lines as discussed in connection with FIG. 4. These output conductors terminate in individual article monitor 80 to which exit detecting unit output line 71 is also connected. Monitor 80 provides a first output signal on line 81 to article reject unit 90, a second output signal on line 82 to process reject unit 100 and third and fourth output signals respectively on lines 83 and 84 to multiple article monitor 110. Monitor 110 provides an output signal on line 111 to process reject unit 100.

As discussed fully below by reference to specific structure, shown in FIG. 4, for monitors 80 and 110, these monitors are operatively responsive to signals indicative of sensed article characteristics to determine whether the manufacturing process, while faulty in certain of its individual products, may continue in operation with rejection of faulty products, or whether manufacturing under such process should be discontinued and process alterations undertaken. Reject units 90 and 100 may comprise conventional indicators, e.g., lamps illuminated by output signals on lines 81, 82 and 111, systems adapted to delete a rejected article from a production line or systems adapted to vary process characteristics in response to qualitative information provided by the monitors.

For convenience in explaining the operation and elemental structure of the system of the invention,
reference will be made to FIG. 2, which illustrates an exemplary article adapted to be manufactured with the assistance of the system of FIG. 1.

FIG. 2 shows in a phantom outline a thermometer 1 having an indicator portion 2 adapted for insertion into the human mouth for oral temperature measurement. Indicator portion 2 includes a plurality of cavities 3 arranged, e.g., in nine rows, each indicative of an integral temperature degree and, e.g., in five columns, each indicative of a decimal part (0.2) of a temperature degree. Each cavity 3 is filled with a temperature-indicating composition 4 which has different thermal characteristics, e.g., melting point (incipient fusion temperature), than does the composition in any other cavity. As is shown in enlarged scale in FIG. 2, thermometer 1 is comprised of a carrier sheet 5, which may function as the thermometer conveyor. Sheet 5 contains cavities 3 and is comprised of flexible, heat-conductive material, such as an aluminum foil, to insure rapid heat transfer from the test subject to the temperature-indicating compositions in said cavities.

In article processing, such sheet 5 is subjected to a stamping step wherein said cavities are formed and wherein indexing apertures 5a and 5b are cut. Then, carrier sheet 5 is then juxtaposed with a dispensing mechanism such that cavities 3 are each in registry with a dispenser issuing a singular temperature-indicating composition 4. The quality of the completed article of manufacture is dependent primarily upon satisfactory completion of the composition dispensing step, an article having insufficient deposited composition in any cavity being unsuitable for use in providing an indication of decimal temperature between the indicated limits of 96.0°F. to 104.8°F. Thus, in the example at hand, cavity deposition level is the article characteristic subject to sensing by the system of the invention.

Upon completion of composition deposition, the carrier sheet is advanced to the aforesaid sensing position where article quality control and process control information are derived. Thereafter, an indicator layer 6 is applied to the cavities. This layer is adapted to provide a visual indication, e.g., color change, upon melting of composition 4 during article use. A masking layer 7 overlies indicator layer 6. Such carrier sheet assembly, enclosed by protective transparent layer 8 and protective undercover layer 9, is then subjected to a cutting step wherein thermometer 1 is cut from the carrier sheet and readied for use.

Referring again to FIG. 1, cavity deposition level may be sensed by pairs of sensors, 14a and 14b, e.g., phototransistors. Lamp L is associated with the sensors as is a light directing member comprised of channels A, B, and C. Channel C is juxtaposed with one of the aforesaid five columns of thermometer cavities and light from lamp L is conducted to channel C from channel B. Light reflected from the thermometer cavities is conducted through channels C and A to sensor 14a. Sensor 14b is exposed continually to light from lamp L. The light directing member is preferably comprised of a bifurcated optic fiber. As carrier sheet 5 is advanced past channel C, or as this channel is moved relative to the carrier sheet, signals are generated by reflectance (or absorption) of said applied light energy in respect of each of cavities 3. Considering sensing unit 10, and assuming the same to be associated with the decimal part (0.0) column of FIG. 2, sensor 14a may see, in the order of decreasing magnitude, anyone of four reflectances of light applied to the carrier, namely, (1) from bare carrier surface, (2) from depressed bare carrier surface (unfilled cavities), (3) from partially filled cavities and (4) from completely filled cavities. Sensor 14b thus applies to bridge circuit 14c, signals having magnitude according with said light reflectances. Differential amplifier 15 differentiates such signals of sensor 14b with the constant signal from sensor 14b, the other input signals from comparator 16, and provides output signals to comparator 16, having magnitudes inversely correlating with the above-deselected amplitude order. Comparator 16 compares such applied signals with a predetermined reference magnitude established by reference generator 17, e.g., as provided by the wiper arm of an excited potentiometer, and indicative of the minimum acceptable deposition level. Exclusively where an applied signal magnitude exceeds such reference magnitude, the comparator applies an output pulse through pulse shaper 18 to output line 11. Evidently, where each of the nine cavities of the thermometer column sensed by unit 10 is filled to a level above the minimum acceptable deposition level, a succession of nine pulses is provided on output line 11. Article characteristic sensing units 20, 30, 40 and 50 operate in identical manner to channel 10 and incorporate identical structure.

With carrier sheet 5 moving in the direction indicated by the arrow in FIG. 2, i.e., toward sensing position P, and with entry detecting sensor 62, or its energy collector, juxtaposed with the left-hand marginal edge of the carrier sheet, sensor 62 is energized as aperture 5a moves past the sensor. The sensor output, as shaped by pulse shaper 63, is applied through line 61 to the counters 12-52, which are thereby reset to zero count. As the carrier sheet moves into and through sensing position P, deposition count pulses are generated, as discussed immediately above. The counters are reset to zero when sensor 62 is again energized prior to examination of the next succeeding article, e.g., thermometer 1a in FIG. 2.

Counters 12-52 may typically comprise MSI TTL High-Speed Decade Counters, Circuit Type SN 7490N manufactured by Texas Instruments, Incorporated, or like binary-coded-decimal counters having at least an input terminal and a reset terminal and adapted to provide a count inclusive of the maximum number of input pulses which might occur prior to reset. The counter output conductors individually comprise four output lines, denoted by the reference numerals 13a-13d through 53a-53d in FIG. 4. Line 13a indicates an eight count, line 13b a four count, line 13c a two count, and line 13d a one count. The exemplary maximum number of input pulses occurring prior to resetting the counters is nine, and the counter will indicate the same by providing lines 13a and 13d with a positive potential (logical ONE) and lines 13c and 13b with D.C. ground (logical ZERO).

Article monitor 80 comprises a first section, shown in the upper half of FIG. 4, adapted to generate the aforesaid signal on line 81 indicating that the article then under examination should be rejected. Such section includes a plurality of decoders 120, 130, 140, 150 and 160, each receiving signals provided by a one of
counter output conductors 13–53 respectively. Inverters 124, 134, 144, 154 and 164 are selectively interposed between each decoder and positive NAND-gate 170. Gate 170 provides a first input to NAND-gate 180, the second input to which is provided by exit sensor unit output line 71. Gate 180 is connected to output line 81 through inverter 190. The structure of decoders 120–160 is identical and will be described in particular for decoder 120.

Decoder 120 incorporates a positive NAND-gate 121 which receives first and second inputs directly from lines 13a and 13d and receives third and fourth inputs from inverters 122 and 123 which are interposed respectively between gate 121 and lines 13b and 13c. Accordingly, when lines 13a–13d indicate 1001 (nine count), the signals applied to gate 121 are all ONES. Gate 121 responds exclusively to such input condition to generate a ZERO. Such ZERO output of gate 121 is inverted by inverter 124 and gate 170 thus receives a ONE from the inverter under this singular condition. Under all other gate input conditions, the gate 121 output is ONE, i.e., whenever the count made by counter 12 (FIG. 1) is less than nine.

Where each of counters 12–52 indicates a nine count, gate 170 receives ONES at all of its input terminals and, exclusively under this condition the gate generates a ZERO. Evidently, only where an article of manufacture exhibits all essential characteristics will gate 170 provide a ZERO.

When the article under examination departs from the sensing position aperture 5b of carrier sheet 5 passes exit sensor 72 and the sensor is energized. Pulse shaper 73 thereupon pulses line 71 which thus changes state momentarily from its normal ZERO to provide a ONE to gate 180. Gate 180 logic, as in the case of gates 170 and 121, provides for the generation of a ZERO only where both inputs thereto are ONES. For the singular condition described above, i.e., nine counts in each of counters 12–52, the upper input to gate 180 provided by gate 170. Gate 180 is thus interconnected, for an acceptable article, gate 180 thus generates a ONE. Inverter 190 changes such gate 180 output to a ZERO and line 81 accordingly indicates that the article under examination is acceptable.

Under all examining conditions other than that described, i.e., where one or more of counters 12–52 count to less than nine, gate 170 provides a ONE output signal and line 71 also exhibits a ONE upon occurrence of article exit from the sensing position. Gate 180 accordingly generates a ZERO and inverter 190 applies a ONE to line 81, indicating that the article under examination fails below requisite standards.

All of the inverters used in the above-described section of monitor 80, e.g., inverters 122, 133, and all inverters discussed hereinafter, may comprise HX Inverters SN 7404N, provided by the aforementioned manufacturer. NAND gates employed in such section and those discussed hereinafter may be procured also from said manufacturer. Two-input NAND-gates SN 7400N may be used directly for gates having two inputs, e.g., gate 180. For NAND-gate 121, the four-input NAND-gate SN 7420N may be employed directly. For NAND-gate 170, five inputs are required and use may be made of NAND-gate SN 7430N, by connecting to the logic supply through a resistor, three of the eight input terminals thereof.

The lower section of monitor 80 is adapted to generate the line 82 signal, which serves to indicate that the manufacturing process then in operation should be discontinued for the reason that an individual article exhibits excessive deficiencies, e.g., has 40 or less cavities containing sufficient temperature-indicating composition. To this end, this section performs a summation of information derived from all of counters 12–52 in respect of each article examined. Four-bit full adder 200 receives information from lines 13a–d and 23a–d, thereby summing the contents of counters 12 and 22. Four-bit full adder 210 performs a summation of the contents of counters 32 and 42 by receipt of information from lines 33a–d and lines 43a–d. In use of commercially available circuit elements discussed below, four-bit full adders 200 and 210 provide carry signals (2ª) respectively on lines 201 and 211 and apply their non-carry output information up to a maximum sum of 2ª–1 to four-bit full adder 220. This full adder provides its carry signal (2ª) on line 221 and its non-carry information (2ª–1) is applied to four-bit full adder 230. Adder 230 performs a summation of such composite non-carry information (2ª–1) from counters 12, 22, 32 and 42 and the contents of counters 52 derived through lines 53a–d. The resultant non-carry information (2ª–1) in respect of all of counters 12–52 is provided on lines 232–235 to comparator 240.

The carry information of four-bit full adders 200, 210 and 220 is applied to two-bit full adder 250, the output of which is applied in conjunction with the carry information of adder 230 to two-bit full adder 260. This full adder provides its output information (2ª, 2ª) on lines 261 and 262 to comparator 240. As will be evident, the decimal capacity of the input lines to comparator 240 is 2ª–1 (63), since six input lines are provided. Such capacity is inclusive of the maximum number of characteristics to be derived from the article employed in the illustrative example, namely, 45 deposition cavities.

The above four-bit full adders 200, 210, 220 and 230 may readily comprise Adders SN 7483N and the two-bit full adders may be Adders SN7482N, both available from the aforementioned manufacturer.

Comparator 240 may comprise any digital comparator adapted, by presetting, to indicate that a binary input thereto is equal to or less than a particular decimal number. Thus, the comparator is programmed to provide a first output signal (ONE) upon receipt of a binary input corresponding to such decimal number and no greater decimal number, for example, 45 (cavities having sufficient composition) and to provide a second output signal (ONE) upon receipt of a binary input corresponding to a lesser decimal number, for example, less than 40. These signals are applied to positive NOR-gate 270. This gate provides a ZERO where a ONE is present at either of its two input terminals and provides a ONE exclusively where ZERO is present at both input terminals. Thus, where the deposition cavities filled sufficiently are less than a predetermined number or equal to such number, gate 270 will provide a ZERO output signal. Positive NOR gate 280 receives an input signal from gate 270 and an input signal from inverter 290. The signal received from inverter 290 is ONE at all times other than the time at which line 72 exhibits a ONE, i.e., at all times other than the occurrence of article exit from the sensing position. Line 82
thus can exhibit a ONE signal only during such exit period and only then in the event that gate 270 also then generates a ZERO output signal. Gate 270 exhibits such ZERO signal only where a ONE signal is applied to either of its input terminals, i.e., when the article under examination exhibits the aforesaid multiple deficiencies. NOR-gates 270 and 280 may comprise Positive Nor-Gates SN 7402N, available from the aforesaid manufacturer.

In the particular form shown in FIG. 4, comparator 240 comprises individual comparators 241 and 242 interconnected by lines 243, 244 and 245. Such individual comparators may comprise Digital Comparator Circuit Type SN 74185N, available from the aforesaid manufacturer, and in this instance, the interconnections provided by lines 243, 244 and 245 is between connectors denoted 3, 13, 12 and 6, 4, 5 respectively, of the two commercially available comparators. By appropriate grounding of selected terminals thereof, the composite comparator may be programmed to any desired number.

Multiple article monitor 110 provides the line 111 signal, which serves to indicate that the manufacturing process then in operation should be discontinued for the reason that a succession of manufactured articles is defective. To this end, monitor 110 receives from monitor 80 a first signal on line 83 indicative of the output of gate 170 and a second signal on line 84 indicative of the output of gate 190.

The counter reset terminal of counter 112 is connected to line 83 by inverter 113 and the counter input terminal is directly connected to line 84. The counter output lines, 114, 115 and 116 respectively indicate four count, two count and one count. Lines 114 and 116 are directly connected to first and second inputs of NAND-gate 118 and a third input of the gate is connected to line 115 by inverter 117. Gate 118 is connected to line 111 by inverter 119.

In operation, monitor 110 is dependent on monitor 80 and, where all articles examined exhibit requisite characteristics, monitor 110 indicates that the manufacturing process thereof is satisfactory by maintaining line 111 continually at ZERO. However, where each article in a predetermined succession of manufactured articles is found to be defective by monitor 80, monitor 110 provides an indication of this occurrence by generating a ONE on line 111. The manner of generation of such line 111 ONE signal is as follows. Where counter 112 applies the pattern 101 on lines 114, 115 and 116 respectively, indicating a count of five, gate 118 receives a ONE at its first and second input terminals directly from lines 114 and 116 and also receives a ONE at its third input from inverter 117. Gate 118, which is of the same type as gate 121, the logic for which has been discussed above, generates a ZERO output signal exclusively in response to this input condition. Line 111 accordingly receives a ONE signal from inverter 119. The input arrangement for gate 118 may evidently be modified such that the gate detects a condition other than that considered, e.g., to provide an output ZERO when any predetermined count is made by counter 112.

Counter 112 provides such pulse pattern, 101 where five successive manufactured articles are indicated by monitor 80 to be defective for not containing all requisite characteristics. To this end, counter 112 may be of the type discussed above in connection with counters 12-52. Counter 112 is thus effective to count pulses applied thereto by inverter 190 and is reset by pulses applied thereto by inverter 113. For each acceptable manufactured article, gate 180 provides a ONE output at all times and, as discussed above, line 81 is accordingly at ZERO. Where a non-acceptable article is noted, gate 180 generates a ZERO coincidently with the application of a ONE to line 71 by article exit sensor 70. Since the inverter 113 output is applied directly to the counter reset terminal, counter 112 is not reset at the time of examination of such non-acceptable article and thus a cumulative count of successive non-acceptable articles is made by counter 112.

By way of example, let it be assumed that a succession of four non-acceptable articles is detected by monitor 80. The four pulses indicating the same on line 84 are counted by counter 112 and no resetting thereof occurs. If the fifth article in the succession is acceptable, line 83 provides a reset signal to the counter prior to stepping of the counter beyond the fourth count. In case, gate 118 does not see the above-discussed input condition, 111, and line 111 is maintained at ZERO throughout the period of sensing the four successive non-acceptable articles.

As will be evident from the foregoing illustrative description, the system of the invention is adapted for detecting, in selective pluralities, requisite characteristics of an individual manufactured article, and, on the basis of such examination, is adapted to make a first determination as to the acceptability or non-acceptability of each manufactured article and to make a second determination on the same basis as to the acceptability or non-acceptability of the process for manufacturing such individual article. The system is further adapted, on the basis of examination of successively manufactured articles, to make a further determination as to acceptability or non-acceptability of the manufactured process.

The particular version of the system discussed in FIGS. 1 and 4 is intended in a descriptive and not in a limiting sense since, as will be evident to those skilled in the art, numerous modifications may be effected therein without departing from the invention. Typically, the article characteristics may be arranged in other than the indicated five pluralities and decoder 120 may be readily altered to detect the existence of other than nine requisite characteristics in each such plurality. The structure of monitor 80 for effecting a collective summation of detected characteristics, irrespective of the selected plurality grouping thereof, may evidently be implemented by circuit means other than the full adding and comparative circuitry particularly discussed. Similarly, monitor 110 may readily be modified to provide determination of process acceptability on the basis of an article succession different from the illustrated succession of five and by circuit means other than that particularly discussed. The true spirit and scope of the invention will be evident from the following claims. What is claimed is:

1. A system for use in article manufacture comprising:
   a. a plurality of first circuit means, each detecting the magnitudes of a selective group of characteristics
of each manufactured article and generating output pulses exclusively on detection of article characteristic magnitudes exceeding a predetermined characteristic magnitude;

b. a plurality of pulse counters, each receiving the output pulses generated by a distinct one of said first circuit means and providing output signals indicative of the number of output pulses generated by said one first circuit means in respect of each manufactured article;

c. second circuit means receiving the output signals provided by each of said counters and generating an output pulse on determining that the output signals provided by at least one of said counters in respect of a manufactured article are indicative of a number less than a first predetermined number; and

d. third circuit means receiving the output signals provided by all said counters in respect of each manufactured article and comprising summation circuit means performing a summation of the numbers indicated by all said counter output signals and comparator circuit means responsive to said summation circuit means for generating an output pulse where said number summation is less than a second predetermined number.

2. The system claimed in claim 1 including means responsive to said second circuit means output pulse for rejecting said article and means responsive to said comparator circuit means output pulse for discontinuing the method for manufacturing said article.

3. The system claimed in claim 1 including fourth circuit means generating an output pulse on the occurrences of second circuit means output pulses in respect of each article in a predetermined succession of manufactured articles.

4. The system claimed in claim 3 including means responsive to said second circuit means output pulses for rejecting manufactured articles and means responsive to said comparator circuit means and said fourth circuit means output pulses for discontinuing the method for manufacturing said articles.

5. The system claimed in claim 1 wherein each said first circuit means comprises sensor means generating signals indicative of the magnitudes of said article characteristics, reference generator means generating a signal indicative of said predetermined characteristic magnitude and a signal comparator receiving said sensor means and reference generator signals and generating said first means output pulses.

6. The system claimed in claim 5 wherein said sensor means comprises a source irradiating said article, a first sensor element exposed to said irradiated article, a second sensor element exposed to said source and a differential amplifier connected to said sensor elements and providing said sensor means signals.

7. The system claimed in claim 1 wherein said second circuit means comprises a coincidence gate and associated circuit means each interconnecting said gate to one of said counters and providing coincidence inputs to said gate upon indication in the output signals of said one counter of said first predetermined number.

8. A system for use in article manufacture comprising:

a. first circuit means detecting article characteristics and generating output pulses exclusively on detection of article characteristics having magnitudes exceeding a predetermined characteristic magnitude;

b. signal counting means providing output signals indicative of the number of output pulses generated by said first circuit means in respect of each manufactured article;

c. second circuit means generating an output pulse upon occurrence of signal counting means output signals indicative of a number less than a first predetermined number in respect of a manufactured article; and

d. third circuit means generating an output pulse when second circuit means output pulses are generated in respect of each successive article in a predetermined succession of manufactured articles.

9. The system claimed in claim 8 including means responsive to said second circuit means output pulse for rejecting said article and means responsive to said third circuit means output pulse for discontinuing the method for manufacturing said article.

10. The system claimed in claim 8 including fourth circuit means generating an output pulse exclusively on determining that the output signals provided by said signal counting means in respect of a manufactured article are indicative of a number less than a second predetermined number.

11. The system claimed in claim 10 including means responsive to said second circuit means output pulses for rejecting manufactured articles and means responsive to said third and fourth circuit means output pulses for discontinuing the method for manufacturing said articles.