

Sept. 2, 1969

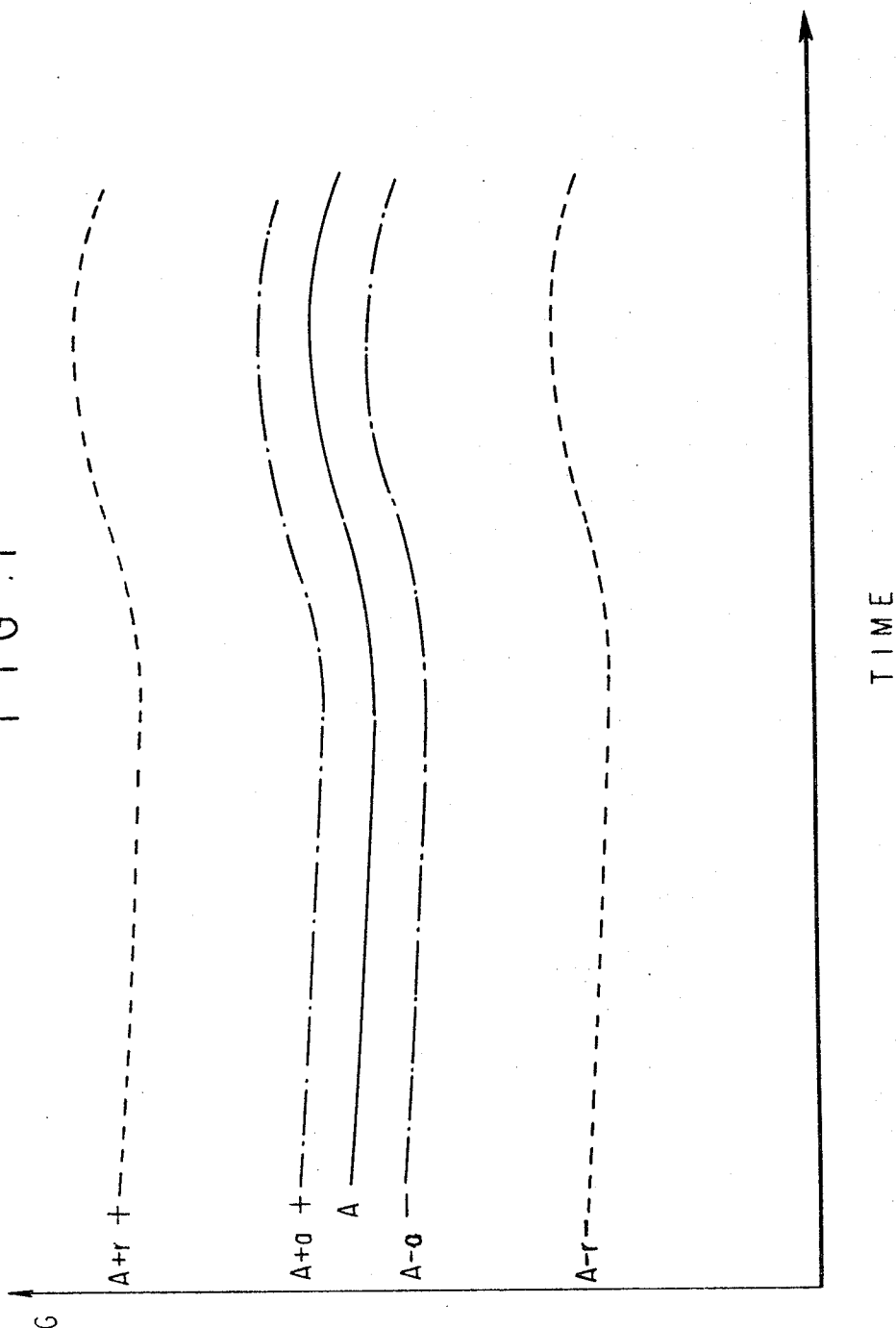
JEAN-CLAUDE ARMBRUSTER
MONITORING AND SORTING ARRANGEMENT
FOR MASS-PRODUCED ARTICLES

3,464,549

Filed Dec. 26, 1967

3 Sheets-Sheet 1

FIG. 1



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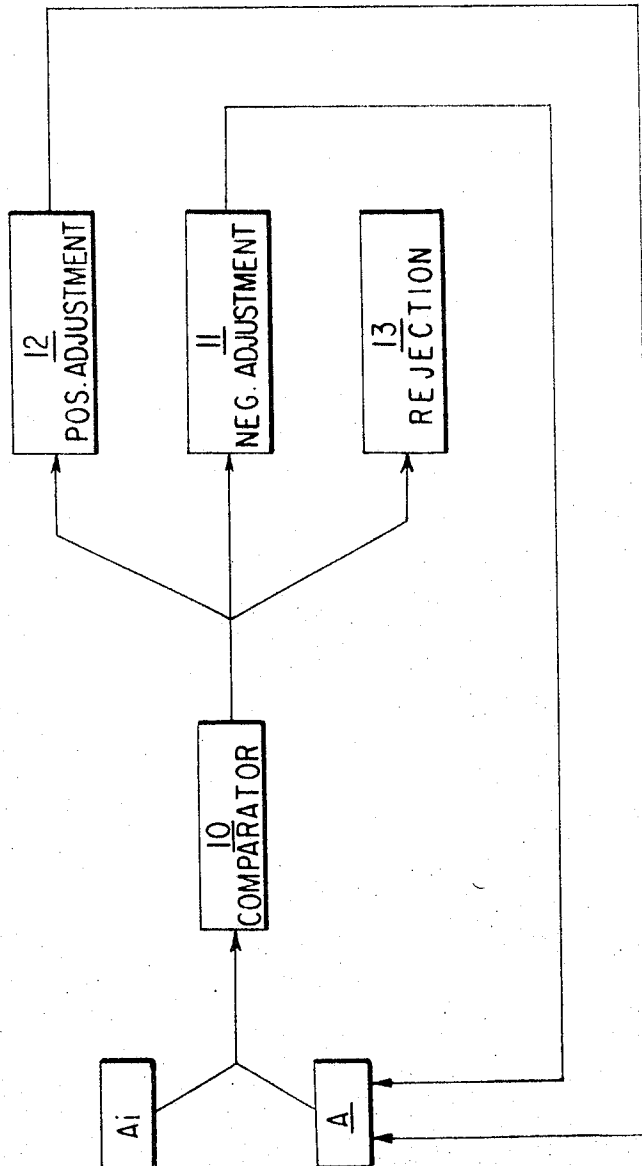
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3 Sheets-Sheet 2

FIG. 2



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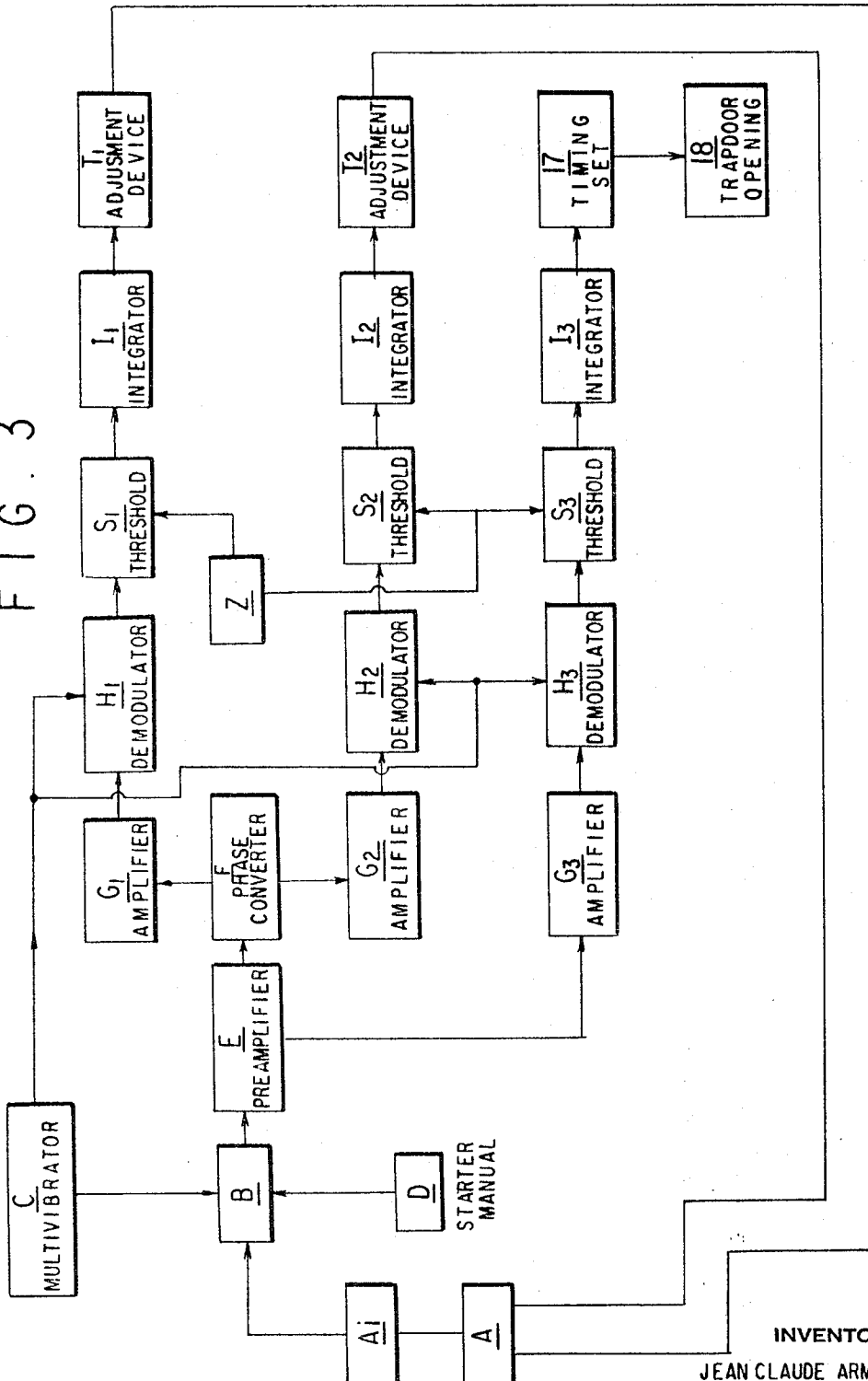
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FIG. 3



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MONITORING AND SORTING ARRANGEMENT FOR MASS-PRODUCED ARTICLES

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U.S. Cl. 209—75

11 Claims

ABSTRACT OF THE DISCLOSURE

Monitoring and sorting arrangement for mass-produced articles, including a comparator device which receives information data measured on manufactured articles and compares this data with a computed mean value A, a positive adjustment path acting on A, a negative adjustment path acting on A and a rejection path, the paths operating in accord with informational data delivered by the comparator device to accept satisfactory articles and reject defective ones.

RELATED APPLICATIONS

There are no related applications of the inventor co-pending.

BRIEF SUMMARY OF INVENTION

The present invention primarily relates to the monitoring and sorting of articles manufactured by mass production techniques.

Known apparatus designed for sorting devices generally use information representing a measurable characteristic. This information is compared to a guide mark or norm and, according to the relationship of the information with respect to the guide mark or norm considered as fixed, the said article is either accepted or rejected.

Usually, the control of a batch of manufactured products is limited to the control or testing of samples. Such a system is open to criticism since there is no evidence or assurance that the tested samples are fully representative of the entire inspected population. Furthermore, the selection of the samples depends on human beings, thus on individual behavior and human error.

The known apparatus also have other inherent drawbacks among which the following may be cited:

The reference used for determining the value of the guide mark or norm must be very stable, otherwise the conditions of the sorting are modified in an unacceptable manner.

On the other hand, when this reference is stable, i.e., when the guide mark value or norm is absolutely constant, the sorting may be either too drastic or too indulgent according to manufacturing fluctuations that are bound to occur.

For instance, the information to be used for sorting a batch of electrochemical cells may be either their electromotive force or their voltage during a very short discharge period. The measured electromotive force, for example, is compared to a reference voltage which must be adjusted according to cell type and must thereafter show great stability at the chosen voltage. Theoretically, such a voltage stability is easy to conceive, but practically cannot be maintained for long periods of time, since it is well known that the reference devices providing the reference voltage are subjected to slow variations, so-called drifts that have not been well mastered.

An object and feature of the present invention is related to a monitoring and sorting system or an arrange-

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ment that not only avoids the above mentioned drawbacks, but permits adjustment of the sorting in an efficient manner whatever manufacturing fluctuations may occur and also give a representative picture of the production for the purpose of its control.

The monitoring and sorting system according to the present invention for mass-produced articles is more especially remarkable in that the grade of the manufacture articles is monitored by the mean value of a characteristic of the articles which have been manufactured during a given previous period of time. This is obtained by registering at every moment at least the values $A_1, A_2, \dots, A_i, \dots$ of a characteristic of successive articles of rank 1, 2, ..., i, ..., the instantaneous mean value A being determined for at least a certain number of lately measured characteristics A, the mean value A being adjusted as a function of the last-measured value A_{i+1} each time the said value A_{i+1} is outside of the limits of the intervals $(A+a^+; A-a^-)$ and the selected articles A_i are comprised in an interval $(A+r^+; A-r^-)$.

By this procedure, it is possible to determine at every moment the more likely value of the production represented by the instantaneous fluctuating mean A of all the information coming from the measurements at a given time on all the articles. The evolution of this mean related to a determined period of time provides a strictly representative picture of the production during this period. Therefore, the system of the present invention permits one to check the production, for example, from day to day, by determining its fluctuations and eventually the irregularities in the production lines.

The system according to the invention permits one also to reject all defective articles showing characteristics too widely different from the normal and instantaneous fluctuating mean value of the production. Since the mean value is fluctuating and shows at every moment the average characteristic of the production, no risk can occur from too indulgent or too drastic sortings because of temporary, seasonal or climatic variations of the mean value A, or drifts of the so-called fixed guide mark or norm.

According to another feature of the invention, the instantaneous fluctuating mean A is adjusted either by an increase or a decrease of a small constant value only when the value A_i is outside of the limits of the above-mentioned interval $(A+a^+; A-a^-)$ and respectively when A_i is over or below the mean value A previously displayed.

Therefore, the informations A_i contained within the interval $(A+a^+; A-a^-)$ do not affect the mean value A whereas if the numerical value A_i of the information is superior to $(A+a^+)$ the fluctuating mean value A will be increased by a low constant value, and if the value A_i is inferior to $(A-a^-)$ the fluctuating mean value will be decreased by a low constant value. Operating in this way, the resulting control is very progressive and not much affected by unavoidable manufacturing hazards.

When the production is steady, i.e., when the mean A does not vary much, the mean A tends to a value departing exactly the number of values A_i superior to $(A+a^+)$ and the number of values inferior to $(A-a^-)$. Through the knowledge of the statistical distribution of these numerical values, it is always possible to determine the limits a^+ and a^- so that the value A represents the most likely mean of the values representing the measurements.

Conversely, indications on the statistic distribution of the measurements are given by studying the operation of the apparatus itself as a function of the values chosen for the limits a^+ and a^- .

Rejection limits r^+ and r^- are fixed for determining if

an article is to be accepted or rejected, according to the required grade of the sorting. In some cases the measured value A_1 can be limited either in the upper or lower sense. For electrochemical generators such as primary cells for instance, the measured characteristic A being the terminal voltage, only one lower rejection limit r^- is sufficient. But monitoring a size such as a diameter, a length, etc. . . . usually requires two rejection limits, i.e., lower and upper.

Further, the present invention relates to a monitoring and sorting apparatus using the above-described system.

Other objects and features of the invention will become apparent from the following detailed description of the accompanying drawings forming part hereof and wherein as a nonlimitative example:

FIGURE 1 is a graph diagrammatically illustrating the variation of the mean A and of the associated information and rejection limits;

FIGURE 2 is a schematic diagram illustrating an embodiment of the invention; and

FIGURE 3 is a diagram similar to FIGURE 2, including further details.

Referring to the drawings:

In FIGURE 1, the curves are presented with the monitored characteristics G as ordinates as a function of time as abscissae.

If the device of this invention is used for primary cell monitoring and sorting, for instance, the value A_1 can be the electromotive force in volts at each cell terminal. This characteristic is thus measured in volts. Assuming that primary cells of Leclanche type are being monitored, the value of A is normally comprised between 1.5 and 1.8 volts, and for the limits a^+ and a^- the respective values can be fixed, for instance, at $a^+=2$ mv. and $a^-=3$ mv. if a rather accurate selection is needed whereas these could be $a^+=3$ mv. and $a^-=5$ mv. for a less accurate sorting. Naturally the rejection limit r^- depends on the battery type and specific grade of quality. For instance, the rejection limit can be comprised between 10 and 150 mv. In the present case of electrochemical cells, no upper limit for r^+ is necessary since cells with higher electromotive forces can be used without trouble.

In the FIGURE 1, the fluctuation of the values A , $A+a^+$, $A-a^-$, $A+r^+$ and $A-r^-$ are schematically shown as smooth curves. Since the corrections or adjustments of the value A are preferably brought with small constant quantities, the curves really should appear in FIGURE 1 as comprised of plateaus or steps. However, as such steps are slight (equivalent to the chosen value for A adjustments) the curves have been drawn as smooth lines for convenience.

FIGURE 2 shows diagrammatically the component parts of a device designed to work out the informations according to the invention. It will be assumed, for instance, that the device is used for primary cell monitoring and sorting and that the measured characteristic G is the cell electromotive force, the information being delivered from the cells tested as electric signals. It is well understood, should the measured characteristic be different and not directly delivering any electrical signal, that other measuring means can be provided, implying no modification in the principle of the invention.

From FIGURE 2, it can be seen that the value A_1 of an article, e.g., the electromotive force of a primary cell, for instance, is directly compared to the fluctuating mean value A previously obtained from preceding manufactured primary cells. An information signal results from the comparison of the said values and is injected into the comparator 10. If the value A_1 is comprised between $(A+a^+)$ and $(A-a^-)$ the article is accepted and no adjustment signal is sent for modifying the value A . If the value A_1 exceeds the value $(A+a^+)$, a corresponding signal is injected into 12 which, in turn, sends an adjustment signal to increase slightly the value of A by a fixed constant value. If the value A_1 is lower than the value

$(A-a^-)$ a signal is injected into 11 which in turn sends an adjustment signal to decrease slightly the value of A by a fixed constant value. Further, if the value A_1 is lower than $(A-r^-)$, a corresponding signal is injected into 13 so that the article of the rank i is rejected. As it has been mentioned hereabove, in this case there is no need to reject a cell having an electromotive force exceeding $(A+r^+)$.

It should be noted, that at the starting of a production line, the mean A must be arbitrarily fixed at a possible value so that the device can be started.

FIGURE 3 shows diagrammatically a device according to the present invention and more particularly designed for monitoring and sorting of cells. Monitoring and sorting of cells raise very arduous problems because the standard deviations composing the statistical distribution of electromotive forces are rather small, approximately a few millivolts, so that the controlling device has to be highly accurate and sensitive.

Although the values of the standard deviations are small, it is nevertheless necessary to provide electrical circuits supporting high input voltages, a thousand times greater than needed for a normal use based on standard deviations of a few millivolts only. Indeed, a shorted primary cell, or the lack of a cell in the moving line, causes a voltage variation comprised between 1 and 2 volts. On the other hand, in view of a desire for obtaining a fast operation, the equilibrium must be restored after each pulse in a very short time, below $\frac{1}{2}$ second approximately. This is the reason to convert the initial information corresponding to one potential difference pulse of 50 msec. for instance, into a train of pulses of higher frequency, for example, 2000 c.p.s. By this means, equilibrium recovery can be very fast after an exceptionally strong pulse. The initial 50 msec. pulse injected into B is converted by the multivibrator C into 100 rectangular pulses of 0.25 msec. duration with intermittent stops of the same duration.

The input circuit B is provided to eliminate the base defining the sign of the initial pulse corresponding to the deviation between the electromotive force A_1 of the monitored primary cell and the reference A so that the pulses in the train of rectangular pulses are alternating pulses which are marked by a phase change function of the initial pulse sign.

This train of alternating pulses marked by a phase shift is injected into a preamplifier E where the signals will become usable. The output signal delivered by the preamplifier is simultaneously sent to a phase converter F and to the rejection path 14.

The phase converter F delivers a complementary signal equal to the output signal of the preamplifier but whose phase shift is modified so that its sign is opposite to that of the initial pulse. Therefore, two symmetrical or complementary signals can be used in the positive adjustment path 15 and in the negative adjustment path 16.

The said symmetrical signals are injected into the amplifiers G_1 and G_2 respectively, to be amplified to a few volts signal. This amplification corresponds to a value $k_1 a^+$ for the positive adjustment path and to a value $k_2 a^-$ for the negative adjustment path, coefficients k_1 and k_2 being determined to correspond to a Zener diode threshold. It is well understood that both paths each can be provided with a Zener diode.

Thus, there is always a signal composed of a train of rectangular pulses at the amplifier outputs.

The output signals of amplifiers G_1 and G_2 are then demodulated in demodulators H_1 and H_2 which convert the signals, considered as alternating and marked by a phase shift, into a negative signal. This conversion is carried out by the phase shift in such a way that the alternating signal being converted into the negative signal corresponds to the initial pulse signal, the other symmetrical alternating signal being cut off. Thus, the demodulators H_1 and H_2 let only pass one signal to be com-

pared either to $-k_1a^+$ if it is delivered by the demodulator H_1 in the positive adjustment path or to $-k_2a^-$ if it is delivered by the demodulator H_2 in the negative adjustment path. Demodulator operation is actuated by the selection of the correct phase from the multivibrator C and the number of amplifier line stages, each stage acting as a phase inverter. The signal delivered by the corresponding demodulator attacks either the threshold S_1 of the positive adjustment path or the threshold S_2 of the negative adjustment path, depending on the operative demodulator H_1 or H_2 . Therefore, the signal is always negative at the input of a threshold and only at one threshold of the two paths. Polarization applied to thresholds S_1 and S_2 by a Zener diode is chosen negative. The values $-k_1a^+$ for the positive adjustment path and $-k_2a^-$ for the negative adjustment path are fitted to be equal to the threshold value of the Zener diode.

Then the method is the following: the values a^+ and a^- being fixed as said hereabove, the amplifying factors of amplifiers G_1 and G_2 are chosen in order that the coefficients k_1 and k_2 lead to k_1a^+ and k_2a^- values equal to the Zener diode threshold. In such conditions, a signal attacking either the threshold S_1 or the threshold S_2 will pass through and pass on only if its absolute amplitude is superior to that of the polarization since signal and threshold polarizers are both negative.

This signal being shaped as a train of rectangular pulses and having passed through one of the two thresholds S_1 and S_2 is injected into the corresponding integrator I_1 or I_2 provided to convert the short train of rectangular pulses into one integrated signal, in other words, the output signal can only be used when composed of a certain number of rectangular pulses. Owing to this integration, parasitic signals which do not have enough pulses, are eliminated.

The output signal from one of the integrators I_1 or I_2 launches the corresponding adjustment device T_1 or T_2 (comprising for example, a flip-flop, a relay and a motor) by which the reference value A is consequently modified.

A similar process is established when a signal delivered by the preamplifier goes into the rejection path. This signal is amplified in amplifier G_3 with an amplified coefficient k_3 such that $-k_3r$ is equal to the negative value of threshold S_3 controlled either by the Zener diode controlling threshold S_1 and S_2 or by an independent Zener diode.

The amplifier G_3 output signal is demodulated by the demodulator H_3 so that the alternating output signal from amplifier G_3 is converted into a negative signal if the sign of the initial pulse is negative, or otherwise cut off. The demodulated output signal from demodulator H_3 can pass the threshold S_3 only if its amplitude is higher than k_3r in absolute value. In this case, the single output signal of the threshold is integrated in the integrator I_3 to eliminate parasitic signals. The integrated signal acts on a timing set 17 provided to delay the trap-door opening so that the trap-door opens when the defective cell is just going on it.

In addition, the system comprises a manual device D for its initial turning on.

The above-described system has the further advantage of being spontaneously stabilized. For instance, when the controlled population drifts by a value either over a^+ or below a^- , the system reacting on A tends to bring the value of A closer to the population average. This is the consequence of the fact that the system according to the invention is only sensitive to relative deviations, i.e., that the system reacts as a function of deviations related to the more likely mean value.

What is claimed is:

1. A monitoring and sorting system for mass-produced articles comprising ascertaining values $A_1, A_2, \dots, A_i$ of successive article characteristics of rank 1, 2, $\dots, i$, so that the instantaneous fluctuation mean value A of a selected number at least of the monitored

characteristic value is determined, adjusting the mean value A each time the monitored value of a new article of rank i falls outside the interval $(A+a^+)(A-a^-)$ and sorting the articles by selecting at least one batch whose monitored characteristics are comprised in an interval $(A+r^+)(A-r^-)$ and adjusting the instantaneous fluctuating mean value A with a low constant value whenever the value A_i falls outside said interval $(A+a^+)(A-a^-)$, the said low constant value as the case may be being above and below the mean value A previously ascertained, the values a^+, a^-, r^+ and r^- being adjustable and values of a^+ and a^- being selected so that a mean value A represents the numerical mean of a determined number at least of preceding values A_i .

2. Apparatus for monitoring and sorting mass-produced articles comprising information securing means for registering at every moment values $A_1, A_2, \dots, A_i$ of characteristics of successive articles of ranks 1, 2, $\dots, i$ and delivering pulses consonant therewith, means for computing a mean value A of a determined number at least of the registered values $A_1, A_2, \dots, A_i$ and delivering pulses consonant therewith, comparator means for receiving said first and second-named pulses and delivering signal pulses therefrom resulting from a comparison therein, a positive adjustment means responsive to signals from said comparator means for affecting said second-named means, negative adjustment means also responsive to different signals from said comparator means affecting said second-named means, and rejection means responsive to another signal from said comparator means on an occurrence of value of A_i of an article which is less than the mean value A of a selected rejection limit to reject the article having such value of A_i .

3. Apparatus according to claim 2 including amplifier means in each of said positive and negative adjustment means, and said rejection means.

4. Apparatus according to claim 2 comprising means for converting signal pulses delivered by said comparator means into a train of pulses at higher frequency.

5. Apparatus according to claim 4 comprising means for converting said train of pulses at a given sign into a train of alternating pulses.

6. Apparatus according to claim 5 comprising means for shifting phase of said alternating pulses forward or backward according to the sign of an original pulse.

7. Apparatus according to claim 6, including phase converter means and a rejection means to which the phase shifted and amplified pulses are passed, said phase converter delivering symmetrical signals into negative and positive adjustment means.

8. Apparatus according to claim 7, including amplifier means for said symmetrical signals, and demodulation means for converting amplified symmetrical signals whose phase shift corresponds to an initial pulse sign into negative signals that are passed while cutting off others, integrator means having threshold means receiving the passed signals and launching operation of the required one of the adjustment means.

9. Apparatus for monitoring and sorting mass-produced articles comprising information securing means for registering successive values $A_1, A_2, \dots, A_i$ of characteristics of successive articles of ranks 1, 2, $\dots, i$ and delivering a pulse signal representative of each such characteristics, means for computing a mean value A of a determined number at least of such registered values and delivering pulses consonant therewith, comparator means for receiving said first and second-named pulses and comparing them and delivering alternating pulses characterized by a phase change as a function of the initial pulse sign, preamplifier means into which the phase shifted alternating pulses are delivered to provide output signals, a phase converter and a rejection path to which the output signals are simultaneously delivered, said phase converter delivering symmetrical complementary signals equal to the output signal of said preamplifier but

modified to signs opposite those of the initial pulses to positive and negative adjustment means.

10. Apparatus according to claim 9, wherein the articles monitored and sorted are electrochemical cells and the characteristics of successive cells registered are cell voltages.

11. A system for monitoring and sorting mass-produced electric cells comprising the steps of measuring voltages successive of the cells, ascertaining a mean value of voltages of a selected group of said cells, comparing the measured voltage of succeeding cells with said mean value, altering the instantaneous fluctuating mean value dependent upon departure of voltages of the succeeding cells and rejecting cells whose measured voltages depart

from a selected difference between a measured value of a particular cell and the instantaneous fluctuating mean voltage value.

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U.S. Cl. X.R.

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