

PATENT SPECIFICATION

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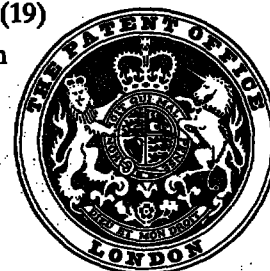
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(54) EVALUATING YARN SIGNALS

(71) We ZELLWEGER USTER LIMITED, CH 8610 Uster, Switzerland a body corporate organised under the laws of Switzerland do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The invention relates to a method of and an apparatus for evaluating a yarn signal having an at least approximately periodic component superimposed on an irregularity.

Modern methods of producing yarns make it necessary to monitor the yarn at the spinning positions continuously and directly. Irregularities at individual spinning positions may thus be detected immediately and corresponding measures taken so that the production of faulty yarns is recognised at the moment of formation and is prevented after a short period.

The plurality of spinning positions used in operation therefore also requires a plurality of monitoring devices. Accordingly, it is desirable to provide a method of monitoring which requires as low an outlay on devices for carrying out the method as possible.

In order to do this, the number of requirements to be met by such monitoring methods has to be restricted to individual criteria. In order to detect the production of faulty yarns at an early stage, it is absolutely essential to determine periodic components superimposed upon the general irregularity caused by the production process. If such periodic components do not stand out particularly in the general irregularity, they may have a very disturbing effect during further processing of the yarn, for example, by producing a so-called Moiré effect which makes the corresponding fabric unusable.

Various methods and apparatus are already known for determining periodic components in the irregularity. However, they are either too slow or require an additional expensive circuit.

By restricting the evaluation of the irregularity or of the yarn signal obtained from the irregularity of the yarn by means of measuring instruments known *per se* merely to the periodic components thereof, it has been found that autocorrelation was initially suitable for this purpose, particularly since it affords a basis for evaluating the yarn signals by means of digital signal-processing methods.

According to the present invention there is provided a method of evaluating a yarn signal having at least one approximately periodic portion superimposed on an irregularity, wherein a yarn signal is obtained from the cross-section or diameter of the yarn by means of a detector, the polarities of discrete values of the yarn signal are determined in a comparator, and a counting device is used to determine how often a coinciding polarity of the discrete values of the yarn signal is found in constant intervals τ , for all time intervals τ in a predetermined range.

The invention also provides an apparatus for evaluating a yarn signal having at least one approximately periodic portion superimposed on an irregularity, comprising a comparator for determining the polarity of discrete values of the yarn signal, a counting device for determining the number of values in constant intervals with coinciding polarity of the discrete values for all intervals in a predetermined range, and a threshold value device for determining if prescribed numerical values are exceeded in the counting device.

In the accompanying drawings:

Figure 1 is a block diagram of a first embodiment of an apparatus according to the invention;

Figure 2 is a block diagram of a second embodiment of the invention;

Figure 3 shows an autocorrelation function of the sign function of a first yarn signal; and

Figure 4 shows another autocorrelation function.

When processing a yarn signal in an 8-bit microcomputer, the yarn signal is quantized into 256 quantization stages. If the number of quantization stages is reduced, two quantization stages are obtained in the limiting case, thus, for example, logic "1" if the signal is positive or logic "0" if the signal is negative. In other words, the sign function of the yarn signal is formed which is defined as

$$\text{sgn} [f(x)] = \begin{cases} 1 & \text{when } (x) \geq 0 \\ 0 & \text{when } (x) < 0 \end{cases} \quad [1]$$

In this case, the autocorrelation function $R(\tau)$ may be calculated very simply as:

$$R(\tau) = \frac{1}{N} \sum_{k=1}^N x(k\Delta t) \cdot x(k\Delta t - \tau) \quad [2]$$

where

k is a constant,

N is the number of tests on the yarn,

Δt is a predetermined time interval between successive tests,

τ is a time delay,

since the EXOR function enters at the position of multiplication and may be effected in terms of circuitry by a gate or by a 2 μ sec command in the case of the microcomputer. This autocorrelation function at the sign function is also known as a polarity coincidence detection.

The analogue-digital converter is reduced to a comparator. When processing with an n -bit microcomputer, n such quantized signals may be introduced in parallel. Such an arrangement is shown in Figure 1. Yarn signals U_{11} , U_{12} , U_{13} received by the detectors 11, 12, 13 are quantized in comparators 21, 22, 23, i.e. are broken down into positive or negative signals q_{21} , q_{22} , q_{23} each of which is fed to an input of a microcomputer 30 for further evaluation.

Since the signal amplitudes have no effect on the value of the sign function, control of amplification or sensitivity is unnecessary. In addition, the comparators 21, 22, 23 may be integrated into the detectors 11, 12, 13. The detectors then emit only two possible initial states, thus increasing the protection from interference.

However, this method of evaluation only allows periodic cross-sectional variations to be determined but not those of increased irregularity.

Another simplification is produced if

$$P = \sum_{\tau=\tau_1}^{\tau_2} R(\tau) \quad [3]$$

is calculated instead of the autocorrelation function $R(\tau)$ according to equation 2 of the sign function. This function may be produced by means of a simple circuit without needing a microcomputer. If the limits τ_1 and τ_2 are selected to be such that they include the range of the possible periods and evaluation continues over a sufficiently long period, this function is also capable of distinguishing yarn signals with a periodic portion from normal yarn. This can be confirmed experimentally.

A circuit arrangement for producing the function P according to equation 3 for a passage is shown in Figure 2.

The procedure begins with the clearing of a counter 36. An amplitude value of the yarn signal U_{11} is then scanned by a "Sample-and-hold" stage 20. A comparator 21 produces the sign function q_{21} , and, depending on the polarity of the scanned value, "0" or "1" appears at the output thereof. This value is read into a serial k -bit shift register 31 and the entire

content is shifted to the right by a bit. The value which is usually in the right hand position usually overflows in this process. This shift register contains the k most recently scanned and the scanned values q_{21} of the signal U_{11} reduced to the polarity symbol thereof. The switch 34 which is connected in parallel with a part 33 of the shift register 31 is now closed so that the contents of the part 33 of the shift register may be rotated once. In this process, each bit is compared with the new bit at the output of the comparator 21 by means of an EXOR gate 35.

If the two bits are equal, the EXOR gate 35 allows the counter 36 to count one unit upwards and if not, to count one unit downwards.

With a purely stochastic signal, the number of coinciding bits will be equal to the number of non-coinciding bits. The counter 36 thus counts upwards as frequently as downwards. Its final value after a monitoring interval of sufficient duration is thus approximately 0. However, if the yarn signal has a periodic portion, coincidences take place more frequently. The counter 36 then counts upwards more frequently than downwards and contains a value at the end of a cycle which exceeds a prescribed reference value so that a digital comparator acting as a threshold device 37 transmits a pulse to a switching means 38. The switching means 38 controls signalling or adjusting devices which indicate the appearance of yarn signals with periodic portions.

The length of the first part 32 of the shift register 31 determines the value τ , and the length of the entire shift register 31 determines τ_2 . This is illustrated in the following example. If the yarn is scanned at 1 cm intervals and if the entire shift register is 24 bits long with the reading after 10 bits, then τ_1 corresponds to a period length of 10 cm and τ_2 to a period length of 24 cm. However, the detectable range is not thus restricted to a period length of from 10 to 24 cm but includes the range from 5 cm to 24 cm. A period of 5 cm does, in fact, have a first harmonic at 10 cm when the autocorrelation function (ACF) is formed and this first harmonic falls in the directly detectable range of from 10 cm to 24 cm.

The line 40 in Figure 3 shows the ACF $R(\tau)$ of the sign function of a yarn signal with a periodic portion wherein the period length has been determined with τ_x at a peak 41, for example with 15 cm wavelength. The peak 41 means that a predominantly coinciding polarity is determined at intervals of 15 cm, for example, more frequently than in intervals of 20 cm. This peak is repeated at $42(2\tau_x)$, at $3\tau_x$ and so forth, which is fundamental property of the ACF.

The value P according to equation 3 corresponds to the area above the abscissa minus the area below the abscissa. This value is larger if a peak 41 is present as a result of a periodic portion in the yarn signal than when this is not the case.

Since the length of a period which is present in all cases is not known in advance, it is not sufficient to calculate the ACF merely for a particular value of τ . Rather, it is determined for a range $\tau_2 - \tau_1$, in which periods are possible or expected.

Figure 4 shows an ACF 44 with a period of 5 cm. The first peak 45 which represents the fundamental wave lies beneath the range $\tau_1 = 10$ cm to $\tau_2 = 24$ cm which may be measured in the example according to Figure 3. The harmonics with peaks 46, 47, 48 however lie within this range. Periods with shorter wavelengths may thus also be detected with a measurement range τ_2 to τ_1 from 10 to 24 cm.

WHAT WE CLAIM IS:

1. A method of evaluating a yarn signal having at least one approximately periodic portion superimposed on an irregularity, wherein a yarn signal is obtained from the cross-section or diameter of the yarn by means of a detector, the polarities of discrete values of the yarn signal are determined in a comparator, and a counting device is used to determine how often a coinciding polarity of the discrete values of the yarn signal is found in constant intervals τ , for all time intervals in a predetermined range.

2. A method according to claim 1, wherein the yarn signals from a plurality of detectors are processed in a central evaluating device which is provided with the counting device.

3. A method of evaluating a yarn signal substantially as herein described with reference to the accompanying drawings.

4. An apparatus for evaluating a yarn signal having at least one approximately periodic portion superimposed on an irregularity, comprising a comparator for determining the polarity of discrete values of the yarn signal, a counting device for determining the number of values in constant intervals with coinciding polarity of the discrete values for all intervals in a predetermined range, and a threshold value device for determining if prescribed numerical values are exceeded in the counting device.

5. An apparatus according to claim 4, wherein an n -bit microcomputer is used as the counting and evaluating device.

6. An apparatus according to claim 5, wherein each bit of the n -bit microcomputer forms a passage for the evaluation of n -quantized signals introduced parallel.

7. An apparatus according to claim 4, wherein the counting device comprises a divided



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content is shifted to the right by a bit. The value which is usually in the right hand position usually overflows in this process. This shift register contains the k most recently scanned and the scanned values q_{21} of the signal U_{11} reduced to the polarity symbol thereof. The switch 34 which is connected in parallel with a part 33 of the shift register 31 is now closed so that the contents of the part 33 of the shift register may be rotated once. In this process, each bit is compared with the new bit at the output of the comparator 21 by means of an EXOR gate 35.

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2. A method according to claim 1, wherein the yarn signals from a plurality of detectors are processed in a central evaluating device which is provided with the counting device.

3. A method of evaluating a yarn signal substantially as herein described with reference to the accompanying drawings.

4. An apparatus for evaluating a yarn signal having at least one approximately periodic portion superimposed on an irregularity, comprising a comparator for determining the polarity of discrete values of the yarn signal, a counting device for determining the number of values in constant intervals with coinciding polarity of the discrete values for all intervals in a predetermined range, and a threshold value device for determining if prescribed numerical values are exceeded in the counting device.

5. An apparatus according to claim 4, wherein an n -bit microcomputer is used as the counting and evaluating device.

6. An apparatus according to claim 5, wherein each bit of the n -bit microcomputer forms a passage for the evaluation of n -quantized signals introduced parallel.

7. An apparatus according to claim 4, wherein the counting device comprises a divided

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shift register, a switch connected in parallel with one part of the register so that when the switch is closed the contents of the said one part may be rotated, a gate to which the output signals of the comparator are fed via a first input and the values rotating in the shift register via a second input, the gate acting to compare the values contained in the shift register with the new value passing the comparator in such a way that these values coincide a unit is added to a counter and when they do not coincide one unit is subtracted from the counter, the apparatus further comprising a second comparator which assigns to the counter a reliable maximum value and switching means which are activated for indicating periodic portions in the yarn signal when the maximum value is exceeded.

8. An apparatus according to claim 7, wherein the yarn signals of a plurality of detectors are fed to a central evaluation device containing the counting device the shift register, the gate and the counter.

9. An apparatus for evaluating a yarn signal, substantially as herein described with reference to the accompanying drawings.

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