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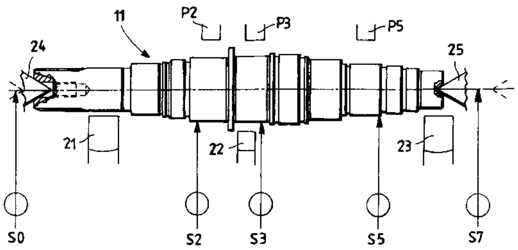
# (54) A process of straightening fragile pieces

(57) A process for straightening fragile pieces (11), which includes a phase for calculating the maximum eccentricity error ($\vec{E}$) of the piece (11) to be straightened, and a multiple number of phases for reducing the error in at least three directions, where the maximum eccentricity error ($\vec{E}$) previously calculated is split up into at least three component vectors ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$), where the component ($\vec{R}1$) is oriented in the direction of the maximum error ($\vec{E}$), while the components ($\vec{R}2$) and ($\vec{R}3$) are oriented with respect to the component ($\vec{R}1$) by an angle of $\pm\alpha$, and where the straightening phases are performed in the direction of the components ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$), with an intensity of blows proportional to the component modules ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$), by appropriately rotating the piece to be straightened (11) by $\pm\alpha$ with respect to the direction of the maximum error ($\vec{E}$), so that the same is oriented, from time to time, in the direction of the components ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$).

Fig.1

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## Description

**[0001]** The object of this invention is a process for straightening fragile pieces.

**[0002]** The operation of straightening fragile pieces is known to be carried out by subjecting the pieces to a flexing action, to the point of producing a strain sufficient to entail a permanent deformation of the material.

**[0003]** This operation is generally performed by straightening machines, in which the piece to be straightened is held between two terminal supports of a point and counterpoint type, and deformed by the action of a punch in the previously established direction of the maximum error.

**[0004]** The quantity of material involved and the size of the deformation is proportional to the error to be reduced, while the remaining value remains within the elastic limits.

**[0005]** As shown, however, the current straightening processes envision a flexing motion in the direction of the maximum error and involve only a modest portion of the material, which is therefore subjected to a relatively high degree of specific elongation.

**[0006]** It is also known that considering the particular nature of the piece to be straightened (for instance: a triangular, square or other form), the straightening may occur in other than the maximum direction.

**[0007]** This approach is valid for tenacious pieces because it shortens the straightening time, but may lead to some frequent breaking or cracking of fragile pieces, because of the required elongation exceeding the material's limits of elongation.

**[0008]** It is also known that the allowable plastic deformation of a material before reaching the breaking point is greater at slow deforming speeds, and that it is moreover preferable to perform the straightening in several cycles rather than at once, but these precautions cannot resolve particularly critical situations.

**[0009]** The scope of this invention is therefore to achieve a straightening process for fragile pieces capable of overcoming the mentioned problems, while in particular avoiding the undesirable rupturing or cracking of fragile pieces.

**[0010]** These and other purposes are achieved by a process of straightening fragile pieces according to claim 1, which is being referred to for brevity.

**[0011]** In an advantageous manner, the quantity of the material involved in the deformation increases, and the required elongation therefore decreases.

**[0012]** This phenomenon advantageously allows avoiding any needless and damaging rupturing or cracking of the fragile pieces. Further characteristics of this invention will be defined in the subsequent claims.

**[0013]** Further scopes and advantages of this invention will become evident from the description and attached drawings that follow, furnished for purely exemplifying and non-limiting purposes, in which:

- Figure 1 represents a schematic view of a piece to be straightened according to the process of the invention,
- Figure 2 represents a block diagram depicting the principal phases of the process of the invention,
- Figure 3 represents a schematic cross-sectional view of a piece to be straightened by a process of the known art,
- Figure 4 represents a schematic, exploded vector view of the process according to this invention, and
- Figure 5 represents a schematic cross-sectional view of a piece to be straightened according to the process of this invention.

**[0014]** The process of straightening according to this invention is performed by using a straightening machine, in which a piece 11 to be straightened is held between two terminal supports of a point and counterpoint type, 24 and 25, and deformed by the action of a punch.

**[0015]** Figure 1 shows a schematic view, for explanatory purposes of the process of the invention, of a piece 11 to be straightened, held by the point and counterpoint supports 24 and 25, while a punch represented in various operating positions P2, P3 and P4 acts on the same.

**[0016]** The piece 11 is also held up by the underlying supports 21, 22, 23 and acted upon by the probes S1, S2, S3, S5 and S7, which serve for determining the degree of eccentricity to be corrected.

**[0017]** This description omits detailing the remaining components of the straightening machine used since those are well known per se in the art, and therefore recalls only the functional elements useful for interpreting and implementing the process of the invention.

**[0018]** In greater detail, the straightening of the piece 11 follows the diagram shown in Figure 2, both by determining the direction of the maximum error by methods already known in the art, as well as by utilizing the probes S1, S2, S3, S5 and S7.

**[0019]** A method for determining the direction of the maximum error which can also be applied in this context is described in the patents IT 1078390 and IT 1196969.

**[0020]** According to this method, the piece 11 to be straightened is rotated on its supports of the point and counterpoint type 24 and 25, while one or more sensors, acting on the periphery of the piece 11, emit a signal proportional to the apparent radius of the piece 11, with respect to the axis identified by the supports 24 and 25.

**[0021]** This signal, generated by the probes S1, S2, S3, S5 and S7, is processed according to a mathematical development of the Fourier series and in particular determined by the first harmonic of the Fourier series, so as to position the piece 11 by rotating it to the point corresponding to the maximum value of said first harmonic.

**[0022]** This operation is shown in a schematic manner by the block 12 in Figure 1.

**[0023]** The process further outlines a parameter for every straightening phase, which defines the threshold error over which the application of the process of this invention begins.

**[0024]** This threshold is related to the maximum allowable deformation of the material, and is experimentally determined.

**[0025]** This choice is indicated in a schematic manner by the block 13. If the value of the mentioned parameter is less than the threshold value, the process immediately proceeds to the block 14 indicating the performance of a conventional straightening procedure, which is eventually repeated as often as needed.

**[0026]** In the opposite case, in which the value of the mentioned parameter is higher than the threshold value, the process moves on to block 15, which indicates the first phase of the process according to the invention.

**[0027]** In this phase, the maximum error previously calculated and designated by $\vec{E}$ is split up in three identical components in a module, indicated by ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$), respectively.

**[0028]** The component $\vec{R}1$ is oriented in the direction of the maximum error, while the components $\vec{R}2$ and $\vec{R}3$ are oriented with respect to $\vec{R}1$ by $\pm\alpha$ .

**[0029]** It should be noted that the vector sum of $\vec{R}1$ + $\vec{R}2$ +$\vec{R}3$ must equal the error $\vec{E}$ to be reduced, as shown in Figure 3.

**[0030]** A particularly preferred value of the angle $\alpha°$ is 30°, so that in this case the components $\vec{R}2$ and $\vec{R}3$ turn out to be oriented with respect to $\vec{R}1$ by ± 30°.

**[0031]** Block 16 therefore performs a straightening phase in the direction $\vec{R}1$ in which the intensity of the blow or blows is proportional to the module of this vector.

**[0032]** Subsequently the piece 11 is rotated by $\alpha°$ in such a way to be oriented according to the direction $\vec{R}2$ and, in block 17, a straightening phase is performed in which the intensity of the blow is proportional to the module of the vector $\vec{R}2$.

**[0033]** The piece 11 is finally rotated by $\alpha°$ so as to be oriented in the direction $\vec{R}3$ and block 18 performs a further straightening phase in which the intensity of the blow or blows is proportional to the module of the vector $\vec{R}3$.

**[0034]** This sequence of operations is eventually repeated for the necessary number of times, while the punch is eventually placed in various operating positions.

**[0035]** A variant of the process of the invention allows utilizing a number of vector components above three, if the size of the initial error is such as to produce three components above the threshold defined as the maximum capable of being straightened.

**[0036]** Moreover, it is possible to exclude straightening directions which are precluded by geometric characteristics of the piece 11 to be straightened.

**[0037]** Thanks to the application of the process according to the invention, the quantity of material involved by the deformation increases, and the required elongation $\varepsilon$ consequently decreases.

**[0038]** In conclusion, the error to be straightened is split up into at least three vectors $\vec{R}1$, $\vec{R}2$, $\vec{R}3$ of an identical module but phased out by an angle $\alpha°$ from each other, straightened in sequence.

**[0039]** The phases of the process of the invention may be performed automatically, by equipping the straightening machine with a processing program.

**[0040]** The above description clearly outlines the characteristics and the advantages of the straightening process for fragile pieces as an object of this invention.

**[0041]** It is finally clear that numerous variants may be applied to the process as an object of this invention, without thereby abandoning the principles of novelty inherent in the inventive concept.

**[0042]** In the practical implementation of the invention, the materials, shapes and dimensions of the illustrated details may be of any kind, depending on the requirements, and the same may be substituted by others of a technically equivalent type.

## Claims

1. A process for straightening fragile pieces (11), **characterized in that** it includes a phase for calculating the maximum error of eccentricity ($\vec{E}$) of the piece (11) to be straightened and a multiple number of phases for reducing the error in at least three directions, where the maximum previously calculated error ($\vec{E}$) is split up into at least three vector components ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$), where the component ( $\vec{R}1$) is oriented in the direction of the maximum error ($\vec{E}$), while the components ($\vec{R}2$) and ( $\vec{R}3$) are oriented at an angle with respect to the component ($\vec{R}1$) by $\pm\alpha$ , and where the mentioned straightening phases are performed in the direction of the components ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$) with an intensity of blows proportional to the modules of the components ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$), by appropriately rotating the piece (11) to be straightened, so that the same is from time to time oriented in one of the directions of the components ( $\vec{R}1$, $\vec{R}2$, $\vec{R}3$).

2. A process according to claim 1, **characterized in that** the mentioned first straightening phase is performed in the direction of the component ($\vec{R}1$), that the piece (11) receives at least one blow of an intensity proportional to the module ($\vec{R}1$), that the mentioned second straightening phase is performed by rotating the piece (11) by an angle of $+\alpha°$ with respect to the direction of the maximum error ($\vec{E}$) so that it is oriented in the direction of the subject component ($\vec{R}2$) and receives at least one blow of an intensity proportional to the module of ($\vec{R}2$), and that the mentioned third straightening phase is performed by rotating the mentioned piece (11) by an angle of $-\alpha°$ with respect to the direction of the maximum error ($\vec{E}$) so that it is oriented in the direction of the mentioned component ($\vec{R}3$) and receives at

least one blow of an intensity proportional to the module of ($\vec{R}3$).

**3.** A process according to claim 1, **characterized in that** the mentioned component vectors ($\vec{R}1$, $\vec{R}2$, $\vec{R}3$) have an identical module.

**4.** A process according to claim 1, **characterized in that** the mentioned angle $\alpha$ has a value essentially equal to 30°.

**5.** A process according to claim 1, **characterized in that** the mentioned phase of calculating the maximum eccentricity error ($\vec{E}$) of the piece (11) to be straightened is performed by rotating the mentioned piece (11) on its terminal supports (24, 25) while one or more sensors, acting on the perimeter of the piece (11), emit a signal proportional to the apparent radius of the mentioned piece (11) with respect to the axis identified by the supports (24, 25), and that said signal is processed so as to determine the first harmonic of the Fourier series associated with the same, so as to position the piece (11), by rotating it, to a position corresponding to the maximum value of said first harmonic.

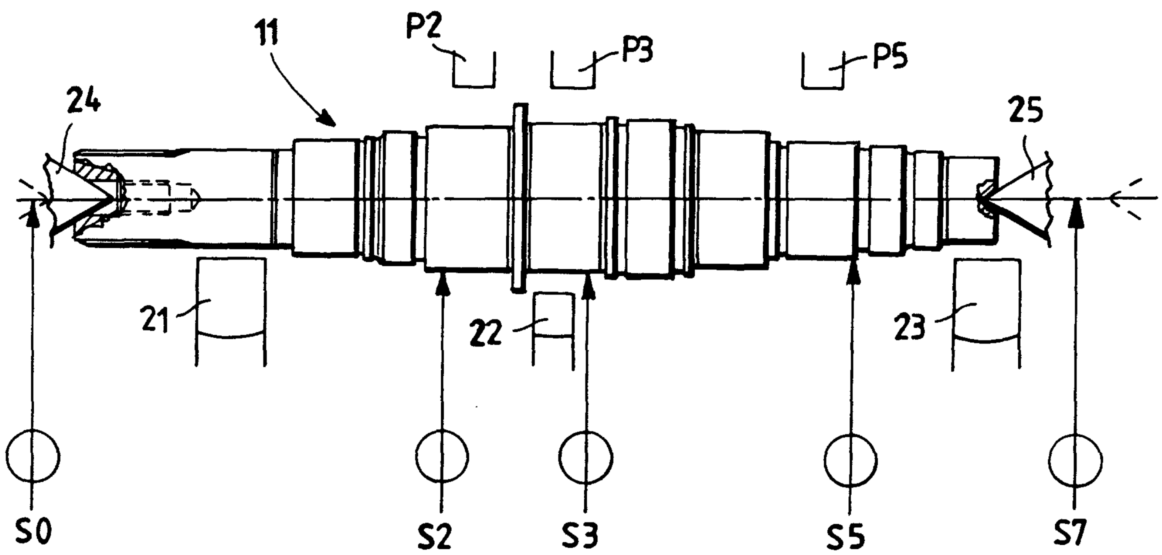
**6.** A process according to claim 1, **characterized in that** it provides for the definition of a parameter for every straightening phase, capable of defining the threshold error above which the application of the mentioned process begins.

**7.** A process according to claim 1, **characterized in that** one or more of the mentioned phases of calculating the error and straightening are repeated as many times as needed to straighten the mentioned piece (11).

**8.** A process according to claim 1, **characterized in that** it provides for the possibility of having a number of vector components of over three, if the size of the initial error is such as to produce three components above the threshold defined as being the maximum capable of being straightened.

**9.** A process according to claim 1, **characterized in that** it provides for the possibility of excluding any straightening directions precluded by the geometric characteristics of the mentioned piece (11).

Fig.1



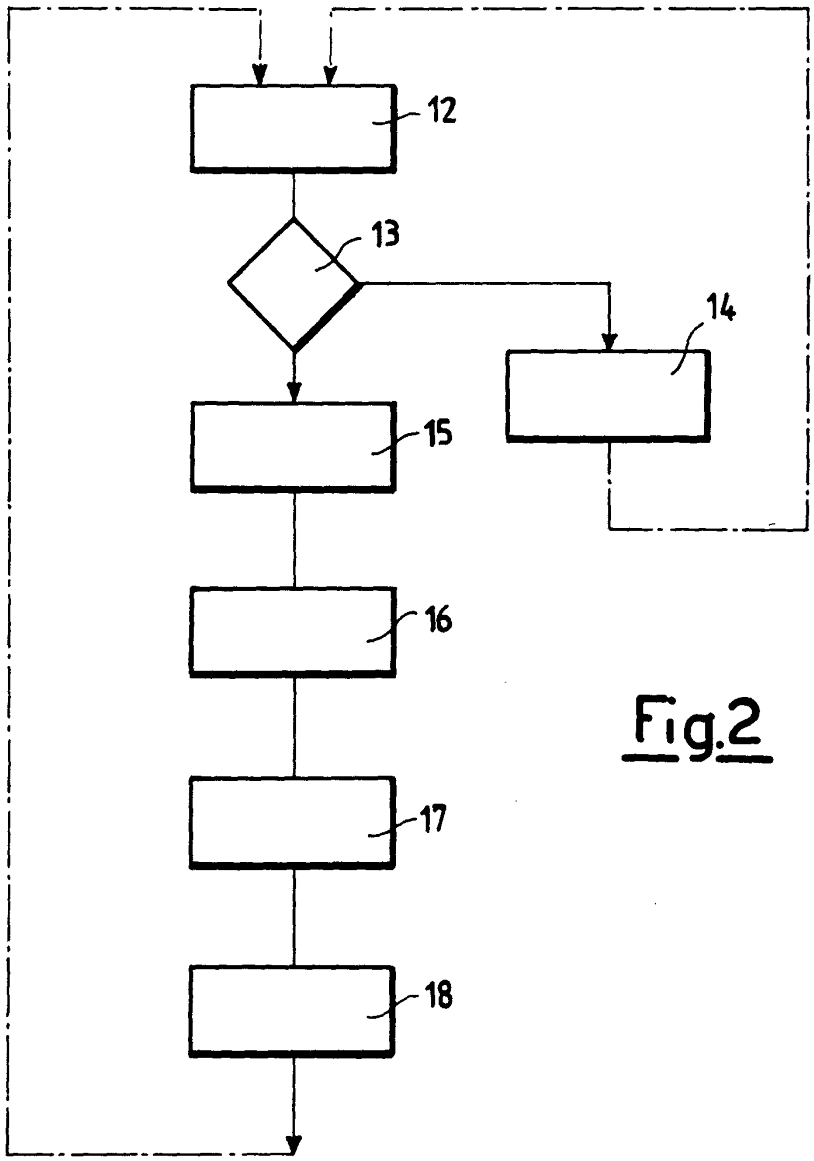



Fig.2

Fig.3

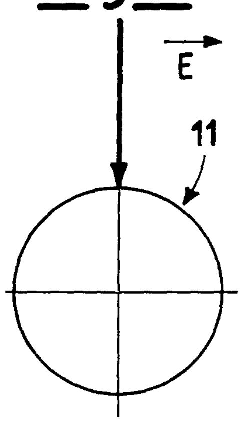



Fig.4

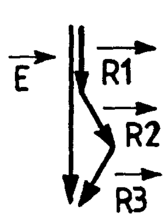



Fig.5