

The present invention refers to a method for automatic convergence measuring and for automatic determination of the corrections to bring about to deflectors to achieve a good convergence with trichromatic cathode ray tubes and to a machine to implement it.

A method and a machine for convergence measuring of a cathode ray tube is already known - see EP-A-0.120.767.

Generally, the deflectors of trichromatic cathode ray tubes show, after manufacturing, convergence errors, even if the manufacturing is very elaborate. At present, to correct these errors, when they are not inconsiderable, we turn to an operator who adjusts each deflector in correct position on a "standard" trichromatic cathode ray tube on which a bar pattern is displayed. Depending on the image deformations which he observes on the screen of this tube, the operator carries out mechanical and/or magnetic adjustments by fixing magnetic correction elements at the places which he considers to be appropriate. The quality of the correction finally achieved depends on the experience of the operator and on his ability to set up a correct correlation between the phenomena observed on the screen of the tube and the adjustments to be carried out. Even with a very experienced operator, such a correction process is relatively slow : 2 to 4 minutes on average for each deflector.

The object of the present invention is a method for automatic convergence measuring for deflectors as well as a method for automatic quality determination for preset deflectors according to a criterion "good-not good" and a method allowing to perform said corrections

in an optimal and quick way without turning to an operator to determine the locations of the correction elements for each deflector and the number of these elements.

Another object of the present invention is also a machine for the automatic and quick supply of the characteristics of the different corrections necessary for each deflector which is simple to use and the cost price of which is the lowest possible.

The method according to the present invention consists in arranging each deflector, mechanically and/or magnetically set or preset, always in the same position on the neck of a reference cathode ray tube, in generating a bar pattern on the screen, in measuring the absolute coordinates of the longitudinal axes of the pattern bars in several points of these bars, preferably in 9 to 25 points, these points being preferably evenly distributed over the surface of the screen and being arranged symmetrically to the vertical and horizontal axes of the surface of the screen, in calculating the deviations of coordinates for the beams of two different guns, in normalizing, i.e. correcting the values obtained to consider the unset positioning of the deflector and/or convergence errors in the center of the tube and/or divergences between the tube used and a theoretical tube and thus obtaining values corresponding to a correct theoretical positioning of the deflector and in deducing therefrom if the used deflector is "good" or "not good", i.e. if its parameters are inside a range of values or not. From these calculated divergences of coordinates, the convergence parameters of the measured deflector are determined in a way known in itself. According to an advantageous feature of the invention, the different

corrections which are eventually required are provided by comparing the normalized values and the obtained convergence parameters with the different values of a table which has been experimentally drawn up beforehand and in providing the corresponding comprehensive or selective corrections to bring about on the deflectors, depending on the different values of a range of normalized values. For deflectors with a field winding which is not yet immobilized in relation to the line winding, the position adjustment of this winding can be determined from these normalized values in a similar way.

The machine according to the invention comprises a measuring bench supporting a reference cathode ray tube, feeding and deflecting circuits for this tube, a pattern generator, a measuring assembly for the coordinates of different areas of the screen of the cathode ray tube, a processing device for the information supplied by the measuring assembly, this processing device comprising circuits for the determination of the coordinates of the axes of luminous bars, circuits for the conversion of the values of coordinates into normalized values, storing devices storing a table about the correspondence between normalized values and necessary corrections, and a comparing circuit.

The present invention will better be understood by reading the detailed description of an embodiment taken as a non-restrictive example and illustrated in the enclosed drawing in which :

Fig. 1 is a block diagram of a machine according to the invention.

Fig. 2 is a simplified plan of a measuring assembly of

the machine according to the invention, arranged on the screen of a cathode ray tube of the machine.

Figs. 3 to 5 are simplified schematic views of bar patterns explaining the method for comprehensive correction according to the invention.

The measuring bench schematically represented in fig. 1 first comprises a cathode ray tube 1 called "reference" cathode ray tube. A classic trichromatic cathode ray tube of very high quality could be used but according to the preferred embodiment of the invention, a three gun tube (arranged in the same way as in a classic trichromatic tube) is used, without mask and comprising a uniform green phosphorous coating. Such a tube is more sensitive than a classic trichromatic tube and allows to obtain a continuous trace on the screen so as to perform measuring of the whole spot.

A classic generator 2 supplies the tube 1 with extra-high tension. A deflector 3 to be measured is placed on the neck of the tube 1. To simplify the handling and to make it automatic, the deflector 3 is fixed in "standard" position in relation to the tube, this position being identical for all the deflectors subject to measuring. The standard position is an average position between the various correct positions of different deflectors of a series of deflectors which are considered as being correctly adjusted and the properties of which have been verified on a measuring bench of the state of the art.

A classic sweep generator 4 feeds the deflector 3. The tube 1 is connected to a pattern generator 5 generating a bar pattern, the brightness of which, considered

transversely, is modulated, for example according to an approximately gaussian law, as described in the patent EP-A-0 120 767 of the applicant. This generator 5 is connected alternately to the three guns of the tube 1.

A measuring assembly 6 is applied on the screen of the tube 1. The assembly 6 comprises several sensors 7 fixed on an appropriate support 8, for example nine sensors placed at "strategic" locations of the screen where the convergence measures are the most useful. These places are, for example, the four corners, the center and the middles of the four sides. Of course, the sensors 7 are placed in such a way and the horizontal 9 and vertical bars 10 of the bar pattern are generated in such a way that the axes of the bars pass approximately through the centers of the sensors 7. As advocated in EP-A-0 120 767, the sensors could be placed perpendicular to the axis of the bars but they should then turn on themselves by 90° when passing from the horizontal bars to the vertical bars. According to an advantageous characteristic of the invention, the sensors 7 are placed at 45° in relation to the axis of the bars and the differences measured just have to be multiplied by $1/\sqrt{2} = \sqrt{2}/2$ to obtain the true values of the differences as cartesian coordinates, these measures being successively performed with horizontal and then with vertical bars (or vice versa).

In a way similar to that advocated by the above-mentioned patent, we obtain with a circuit 11 the convergence measure for a trichromatic tube by measuring the differences of the positions of the bars obtained for two different beams and by multiplying the results of the measures by $\sqrt{2}/2$ if the sensors are inclined at 45° , as advocated above.

Of course, if instead of measuring the convergence of trichromatic tubes, we wish to determine the properties of the deflectors and the corrections eventually necessary, we use preferably green tubes with three guns, without mask - as mentioned above.

The rough measures obtained are then "normalized" with a circuit 12, i.e. they are converted so as to obtain those which would have been obtained, if the deflector was in a "normalized" measuring position. This position is the usual measuring position of a deflector on a cathode ray tube when the convergences in the center are set to zero and when the deflector is turned around the neck of the tube so that the central horizontal bar of the pattern coincides with the mechanical horizontal axis of the envelope (of the screen of the tube) and, when the deflector moves in X and in Y (translation or "tilt") so that the convergence errors of the lateral beams (red and blue) are balanced at the points 6H and 12H (in the middle of the long sides of the screen) for example. The laws of variation of the convergences can thus be established for a type of deflectors, depending on the position of the deflector on the neck of the tube (by rotation or moving in X and Y) and on the configuration of the convergences in the center. The knowledge of these laws allows then to deduce, for a deflector subject to measuring and placed on the neck of the tube in a fixed position, the corrections which have to be brought about to obtain those which would have been obtained if the deflector was in normalized position. These corrections are determined depending on a certain number of indicating factors such as, for example, the convergence errors in the center, the misalignment 3H - 9H of a green pattern bar (i.e. a horizontal bar passing through the center of the screen), convergence symmetry

errors red/blue at 6H - 12H (the different points of the periphery of the screen are marked by analogy with the dial of a clock : 12 o'clock, 6 o'clock etc.).

If we make these variation laws similar to linear laws (which is generally possible with a good approximation ; otherwise, if a higher precision is sought for, more complex laws can be established), we can define said corrections in a simple way according to the following example.

Let P_h and P_v be the rough measures at the point P in relation to the horizontal and vertical bars respectively. Let C_x and C_y be the convergence errors in the center (between the horizontal and the vertical bars respectively) and A_v and C_v the vertical amplitude and the skew determining the convergence symmetry errors at 6H and 12H (i.e. in the middle of the long sides of the bottom and of the top of the screen) of the blue and red beams. These values A_v and C_v are given by the relations

$$A_v = \frac{M_{12H} - M_{6H}}{2} \quad C_v = \frac{M_{12V} - M_{6V}}{2}$$

M_{12H} , M_{6H} , M_{12V} and M_{6V} being the rough measures taken between horizontal bars (H) and vertical bars (V) at the points 12H and 6H of the screen.

The normalized values of these rough measures NH and NV (between horizontal and vertical bars) are given by the relations :

$$\begin{aligned} NH &= PH - a \cdot C_x - b \cdot C_y - c \cdot A_v - d \cdot C_v \\ NV &= PV - e \cdot C_x - f \cdot C_y - g \cdot A_v - h \cdot C_v \end{aligned}$$

In these relations, the coefficients a , b , ..., h are those of said convergence variation laws at the point P for the different corresponding parameters.

All these calculations can be carried out by a computer, programmed in a way comprehensible to those skilled in the art.

The good choice of the position of the deflector to be measured on the neck of the cathode ray tube allows to obtain convergence symmetry errors at $6H/12H$ of relatively weak amplitude (generally less or equal to 1 mm). Thus, in most cases, the convergence variation laws can be made similar to linear laws.

Thanks to the normalization method by calculation described above, a supplementary correction can also be made, representing the eventual deviation of convergence characteristics of the tube on which the measures are made in relation to an "ideal" reference tube. This supplementary correction can be made in a way similar to the normalization for each measuring point.

Based on the normalized values available at the output of the computer 12, a circuit 13 carries out the comparison with the corresponding theoretical values. These theoretical values are stored in a memory of the circuit 13 which compares them with the normalized values.

The difference signal (convergence difference) produced by the circuit 13 is available on its output 13A from which it can be sent to any appropriate processing device, such as storing or recording device or statistical processing device, to control the quality of a manufacturing cycle.

Moreover, the output 13A is connected to a decision device 14 which mainly comprises a threshold circuit. The thresholds of this circuit correspond to the permissible

maximum values for normalized values or to the differences of convergence (permissible differences depending on the specifications or criteria bound to a small number of sensors and to the knowledge of the product). This circuit 14 comprises two outputs : 14A: "Good" (within the tolerance thresholds) and 14B: "Not good". When the deflectors are considered as being "good", there is no need, of course, for any further processing. On the other hand, if they are considered as being "bad", the question of their recovery arises because it is generally possible to correct their convergence errors with magnetic shunts.

A device 15 activated by the output 14B allows the implementation of a first correction level leading to the use, known in itself, of magnetic shunts with a local effect on the screen generally at points of the periphery of the screen. The circuit 15 mainly comprises a storing device in which the characteristics of the different local corrections, which are necessary depending on the different values of the convergence differences, are stored. Since it is generally aimed at to use the smallest number possible of different types of magnetic shunts and to limit the number of their places, a given correction will correspond to a range of several values of convergence differences.

Moreover, the device 15 comprises a comparator connected on the one hand to this storing device and on the other hand to the output 13A of the circuit 13, this comparator supplying the output 15A of the device 15 with the characteristics of the necessary local correction.

This correction method implemented by the device 15 is similar to the method used by experienced operators but

th device according to the invention uses its method more quickly and more precisely (the reactions of an operator can vary during the day depending on his tiredness and on different other elements).

According to the invention, a correction method which is more sophisticated also may be implemented. Then, a comprehensive correction of the image is made : The device according to the invention comprises a device 16 which calculates all significant parameters of an image from normalized measures supplied by the circuit 12. Thus, it can verify the correct symmetry of the image (top/bottom and left/right), the correspondence between the astigmatism situation of the magnetic fields of the measured deflector and the normal situation which should be obtained (reference situation). This device 16 is activated by the output 14B of the circuit 14. The output of the device 16 is connected to a device 17. The device 17 stores the theoretical convergence parameters of the type of deflector being controlled as well as the comprehensive corrections corresponding to the differences between the theoretical and the calculated parameters. These corrections are available at the output 18.

We shall now explain the correction method with reference to the examples of figs. 3 to 5 of the drawing which relate to a very simple example for a possible embodiment.

Let us suppose a deflector, the normalized image of which looks like that which is represented in fig. 3 (in figs. 3 to 5, the full lines correspond to the "red" gun and the discontinued lines to the "blue" gun). If a localized correction of this deflector was made, the points 2H and 10H should be corrected (the convergence

error e_1 at 2H as well as at 10H is much higher than the specifications). These punctual corrections are made, in a way known in itself, and we obtain an image - as represented in fig. 4 - for which the error e_2 in 2H and 10H is approximately half the error e_1 . However, there still remains an important error at 3H - 9H, for which one or several other punctual corrections should be made. On the other hand, if we analyse the parameters of the whole image from the beginning (fig. 3), we deduce therefrom an unbalance 3H - 9H ("cross-over" error) and after having measured the value of it, we can determine the appropriate comprehensive correction. A calculation, made in a way known in itself, indicates that, after the appropriate correction of this "cross-over" error, all points of the image will definitely be within the specification limits. After such a "comprehensive" correction, we obtain an image similar to that of fig. 5. Thus, a correction making the magnetic fields symmetric is made and the image obtained is much more symmetric than the previous ones. Especially all the internal points, the deformations of which are the most noticeable for the interpretation of the quality of the images displayed on the screen, only present weak errors.

Such a comprehensive correction method could eventually be implemented by a very experienced operator, but for an acceptable implementation, the operator should take on many lengthy measures and carry out calculations sometimes less simple than those of the example above, for example in case convergence errors would modify the four corners of the image, what would be damning for a serial production.

According to the method of the invention, the comprehensive correction can, of course, correct other errors simultaneously. According to the analysis of the parameters of the whole image, the problem of the "balance" errors can, if need be, also be solved so that, in combination with the aforesaid "cross-over" correction, the image is practically perfectly symmetric.

In other cases, an astigmatic error of the line or frame field can also be corrected to bring the characteristics of the deflector closer to those of a reference product.

The advantage of the machine to implement the method of the invention consists in the possibility to associate these different corrections very quickly and in an optimum way to determine the most simple and less numerous necessary corrections (generally a comprehensive correction has the same effect or a better effect than several punctual corrections ; moreover, punctual corrections can introduce errors in other places).

The preliminary determination of the position of the shunts ensues experimentally considering the physics of the deflector and the normal knowledge of those skilled in the art.

The different devices 12 to 17 can, of course, be replaced by a single calculator providing all their functions.

Since the sensors 7 have very precise geometrical positions in relation to the screen of the tube 1, they allow the determination of the absolute coordinates of the traces of the beams on the whole screen (after standardization of the machine with a standard deflector

measured beforehand). From these measures of coordinates taken on the monochromatic image (preferably that of the green beam), the machine can calculate, in a way known in itself, all components of the geometry of the image : orthogonality, east-west pincushion distortion and north-south pincushion distortion, geometry trapezoids etc. The horizontal and vertical sensitivity of the deflector can also be measured, i.e. the amplitudes of the image for controlled horizontal and vertical sweep currents.



CLAIMS

1. Method for automatic convergence measuring and determination of the corrections to bring about to deflectors for trichromatic cathode ray tubes, characterized in that each deflector, mechanically and/or magnetically set or preset, is arranged always in the same position on the neck of a reference cathode ray tube, that a bar pattern with crossed bars is generated on the screen, that the absolute coordinates of the longitudinal axes of these pattern bars are measured in several points of these bars, preferably in 9 to 25 points, that the deviations of the coordinates for the beams of two different guns are calculated, that the obtained values are normalized to consider the unset positioning of the deflector and/or convergence errors in the center of the tube and/or divergences between the tube used and a theoretical tube to thus obtain values corresponding to a correct theoretical positioning of the deflector and that the convergence errors of the deflector are calculated from these normalized values.
2. Method according to claim 1, characterized in that the measuring points of the crossed bars are evenly distributed over the surface of the screen, symmetrically to the vertical and horizontal axes of the screen.
3. Method according to any of the preceding claims, characterized in that the reference tube used is a three-gun tube without mask and with an entirely green screen.
4. Method according to any of the preceding claims for deflectors with a field winding which is not yet immobilized in relation to the line winding, characterized in that the position adjustment of this winding is deter-



mined from normalized measures.

5. Method according to any of the preceding claims, characterized in that the convergence differences of the measured deflector are calculated from normalized measures.
6. Method according to claim 5, characterized in that the quality of the deflector is determined by a criterion "good - not good" depending on whether its convergence differences or its normalized values are within a range of values or not.
7. Method according to claim 5 or 6, characterized in that the punctual corrections to bring about to the deflector are determined from the values of the convergence differences of the deflector.
8. Method according to claim 5 or 6, characterized in that from normalized convergence values of the deflector the convergence parameters of this deflector are calculated and the comprehensive corrections to bring about deduced.
9. Method according to any of the preceding claims, characterized in that from the values measured by the sensors with a single beam the components of the geometry of the image of the cathode ray tube are determined.
10. Machine for automatic convergence measuring and determination of the corrections to bring about to deflectors for trichromatic cathode ray tubes, comprising a measuring bench supporting a reference tube, feeding (2) and deflecting (3, 4) circuits for this tube (1), a pattern



generator (5), a measuring assembly (7) for the coordinates of different ares of the screen of the tube and a processing device for the information supplied by the measuring assembly (11 - 18), characterized in that the processing device comprises devices (11) for the determination of the coordinates of the axes of luminous bars produced by the pattern generator, connected to devices (12) for the conversion of the values of the coordinates into normalized values and a device for the calculation of convergence differences (13).

11. Machine according to claim 10, characterized in that the device for the calculation of convergence errors is followed by a decision device (14) with threshold circuits.
12. Machine according to any of the claims 10 or 11, characterized in that the device for the calculation of convergence errors is connected to a device (15) for the determination of punctual corrections.
13. Machine according to any of the claims 10 or 11, characterized in that the device for the conversion into normalized values (12) is connected to a device (16) for the calculation of the parameters for the whole image produced by the pattern generator, connected itself to a device (17) for the determination of comprehensive corrections.