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GB A 2132057	GB 1586201	EP A2 0127482
GB A 2126855	GB 1517119	EP A2 0068420
GB A 2073993	GB 1353147	WO A1 7900717
GB 1588652	GB 1190400	

(58) Field of search
H4F
H4T

(54) **Establishing convergence of plural images on screens**

(57) A plurality of images superimposed to form a composite image on a screen of a television monitor are brought into convergence (register) by forming a reference image on the screen preferably by means of one beam-generating means, the reference image including a plurality of reference points, and superimposing a test image 52 from another beam generating means on the reference image. The test image 52 is similar to the reference image and includes a plurality of adjustment points 51 respectively corresponding to the reference points. The test image includes also at least one correction portion (hatched in Fig. 4A) corresponding to a given portion of the reference image, the correction portion including a given subset (line junctions Ae, Ad, Bd, Be) of the adjustment points. An adjustment point 51 is selected by means of a cursor from within the subset (Ae,Ad,Bd,Be), the position of the selected adjustment point 51, is adjusted with respect to the reference point corresponding thereto, and the positions of the

Continued overleaf . . .

FIG.3

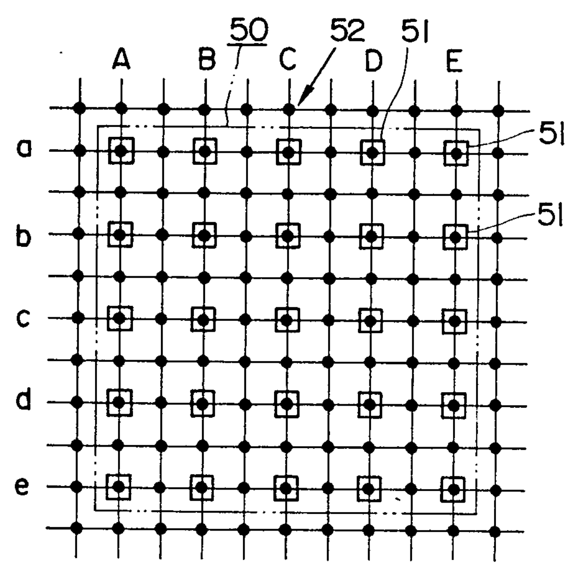
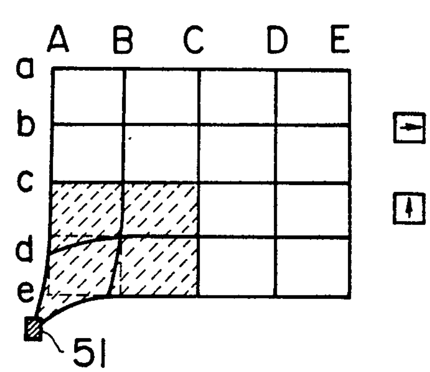


FIG.4 A



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other points within the correction portion are adjusted simultaneously and proportionally, thereby establishing a substantial convergence of the correction portion with respect to the given portion of the reference image. This process is controlled from a keyboard (Fig. 2). The process is repeated for other corresponding image portions as necessary to establish substantial convergence of all corresponding portions of the two images. Convergence of a third image with the first two is established in the same manner. By this means convergence, shape, size and centering errors may be corrected.

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FIG.1

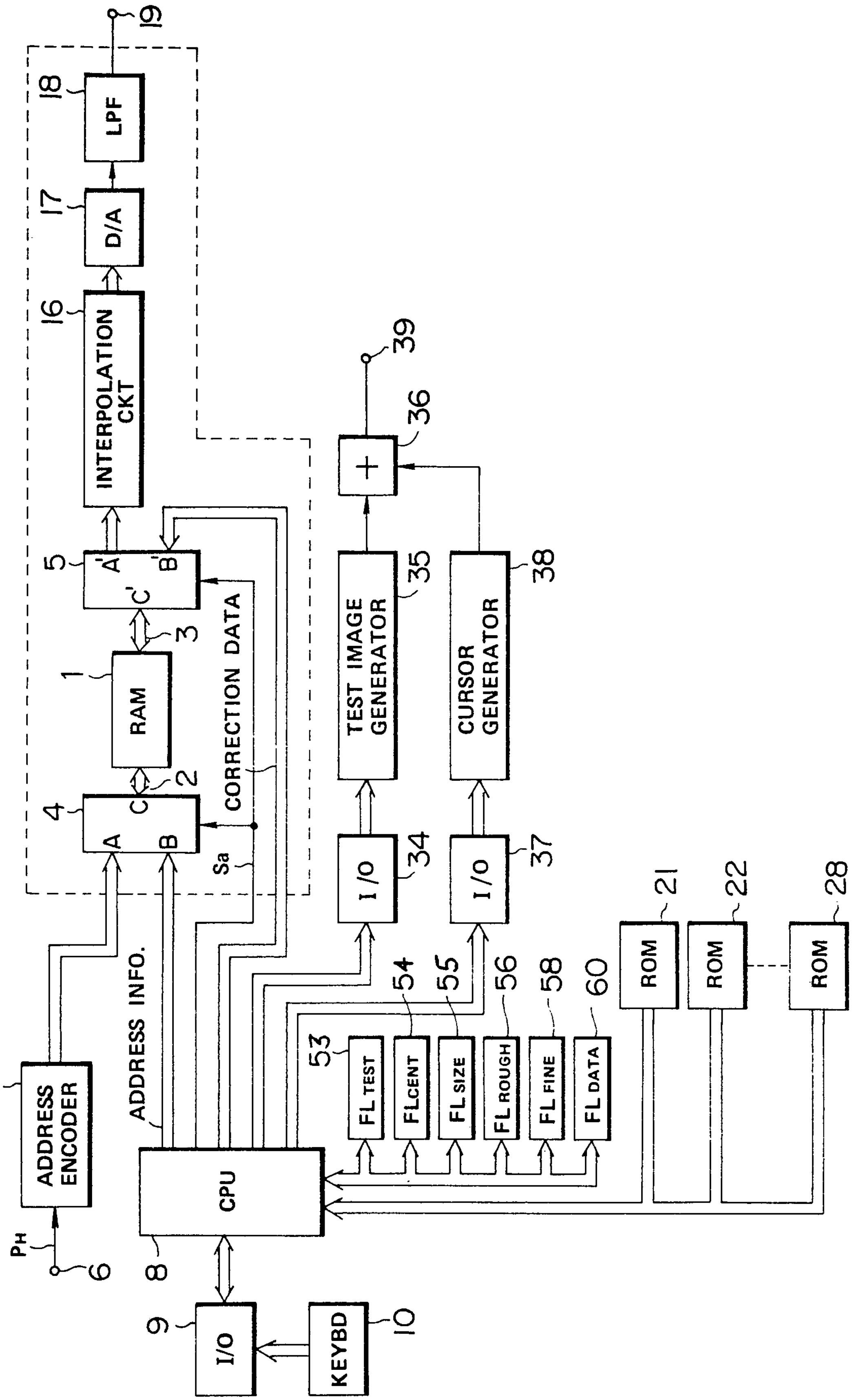


FIG.2

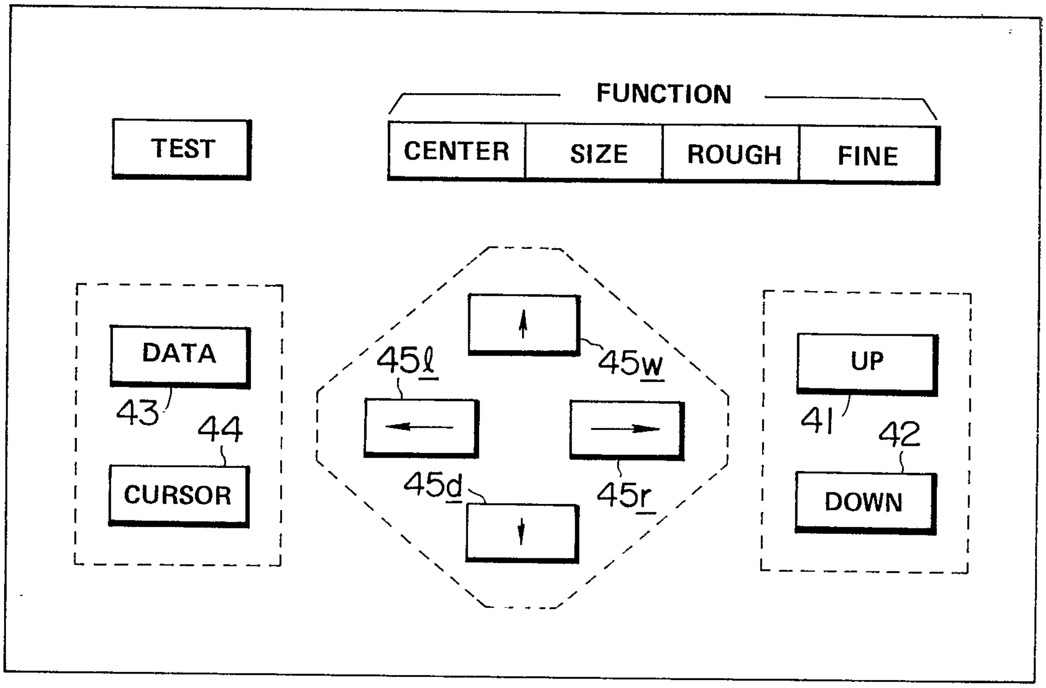
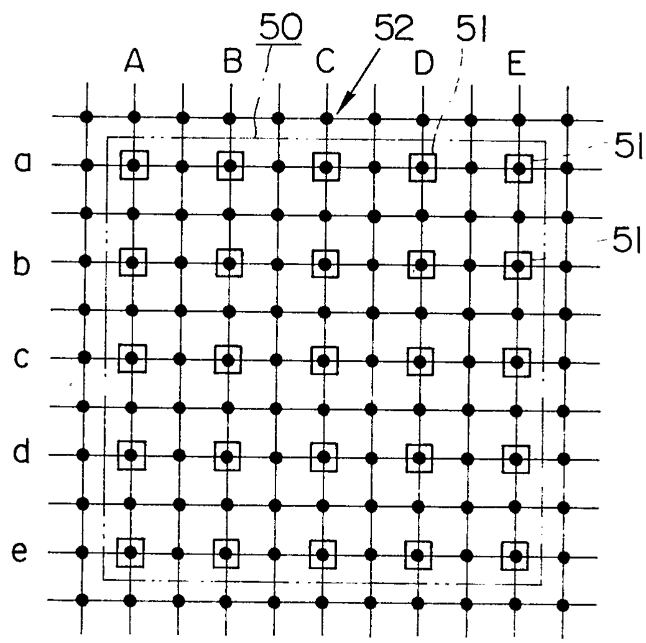

FUNCTION
TEST
CENTER
SIZE
ROUGH
FINE
DATA
43
44
CURSOR
45ℓ
45w
45d
45r
UP
41
42
DOWN

FIG.3


50
52
51
A
B
C
D
E
a
b
c
d
e
51
51

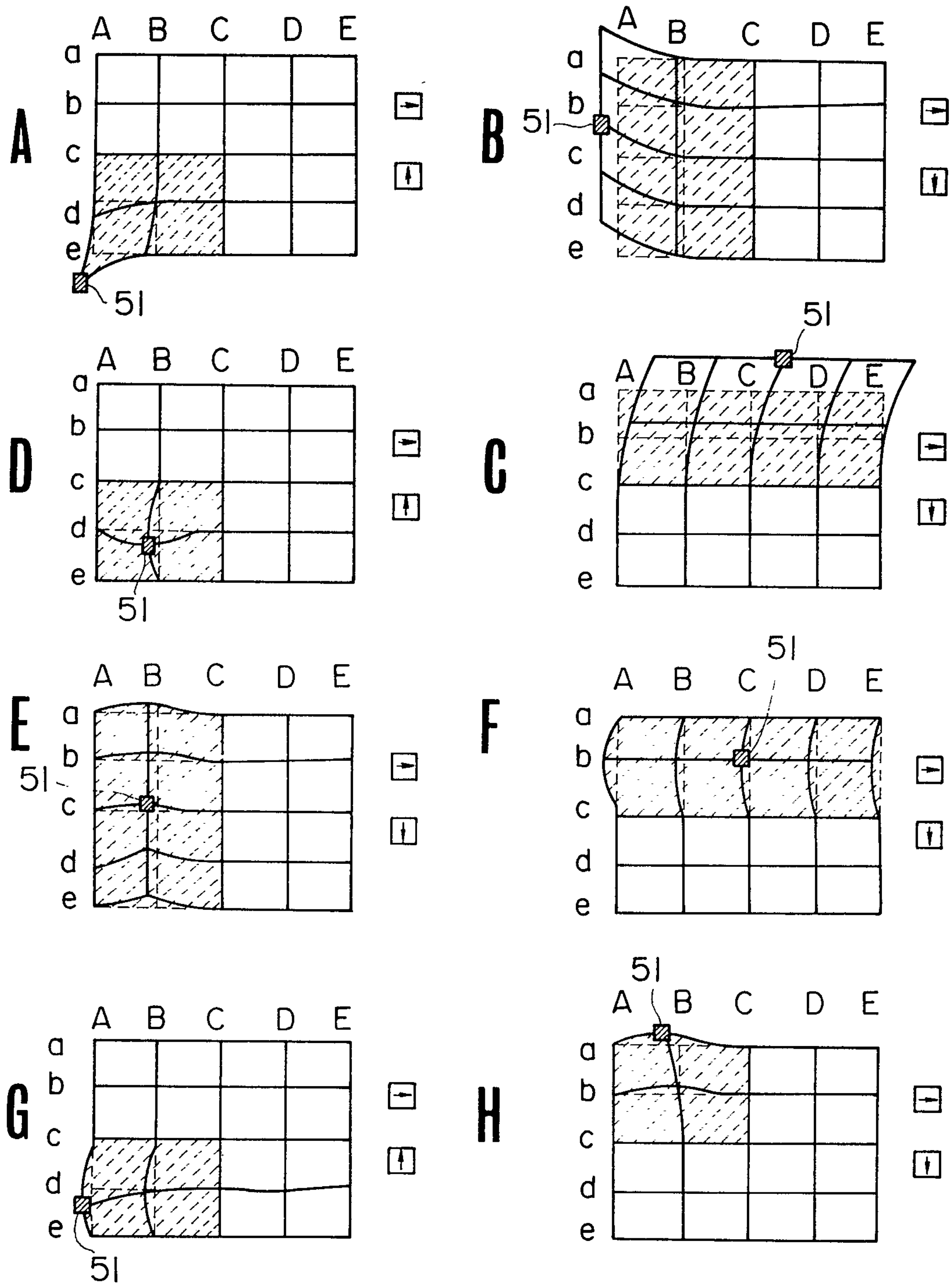


FIG.4

FIG.5

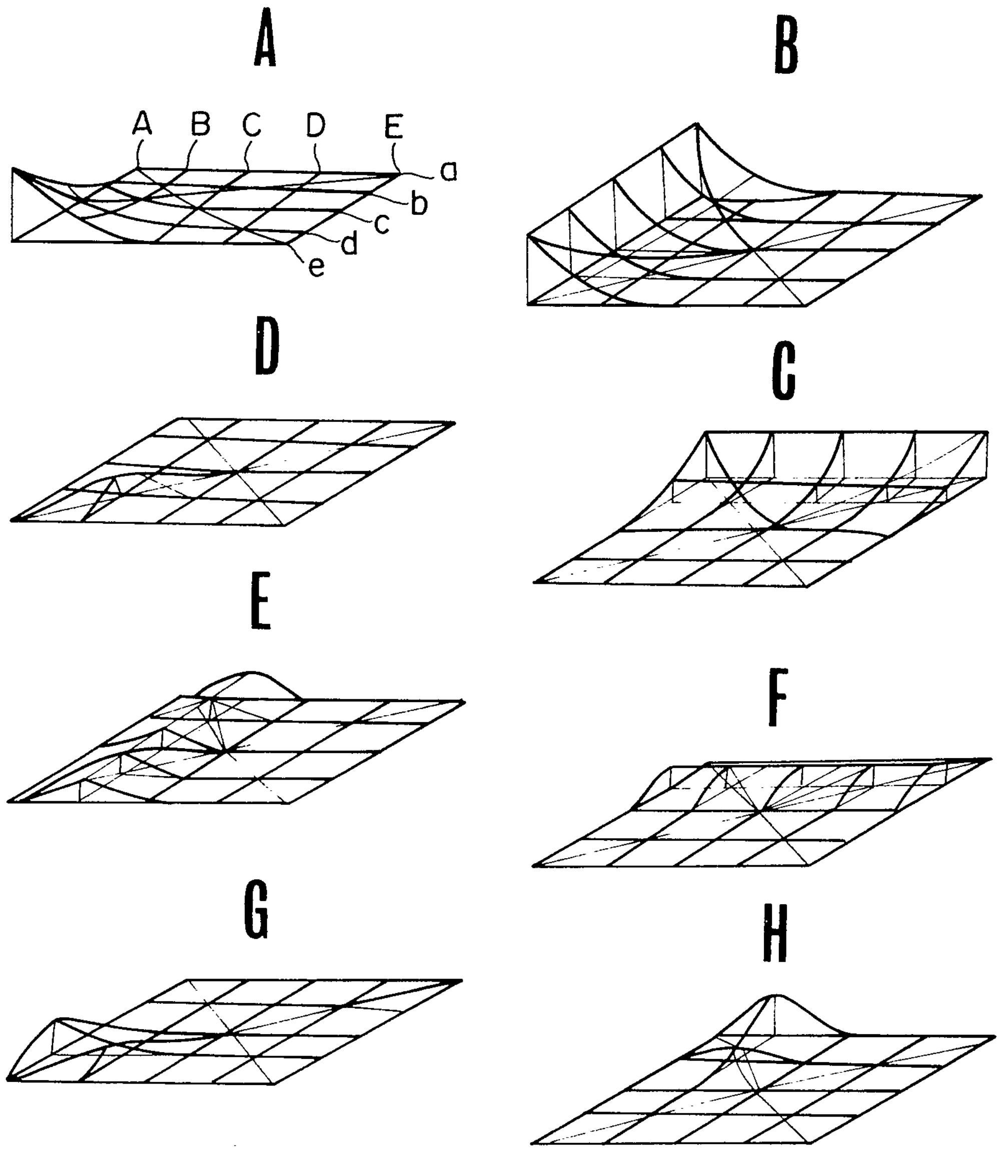
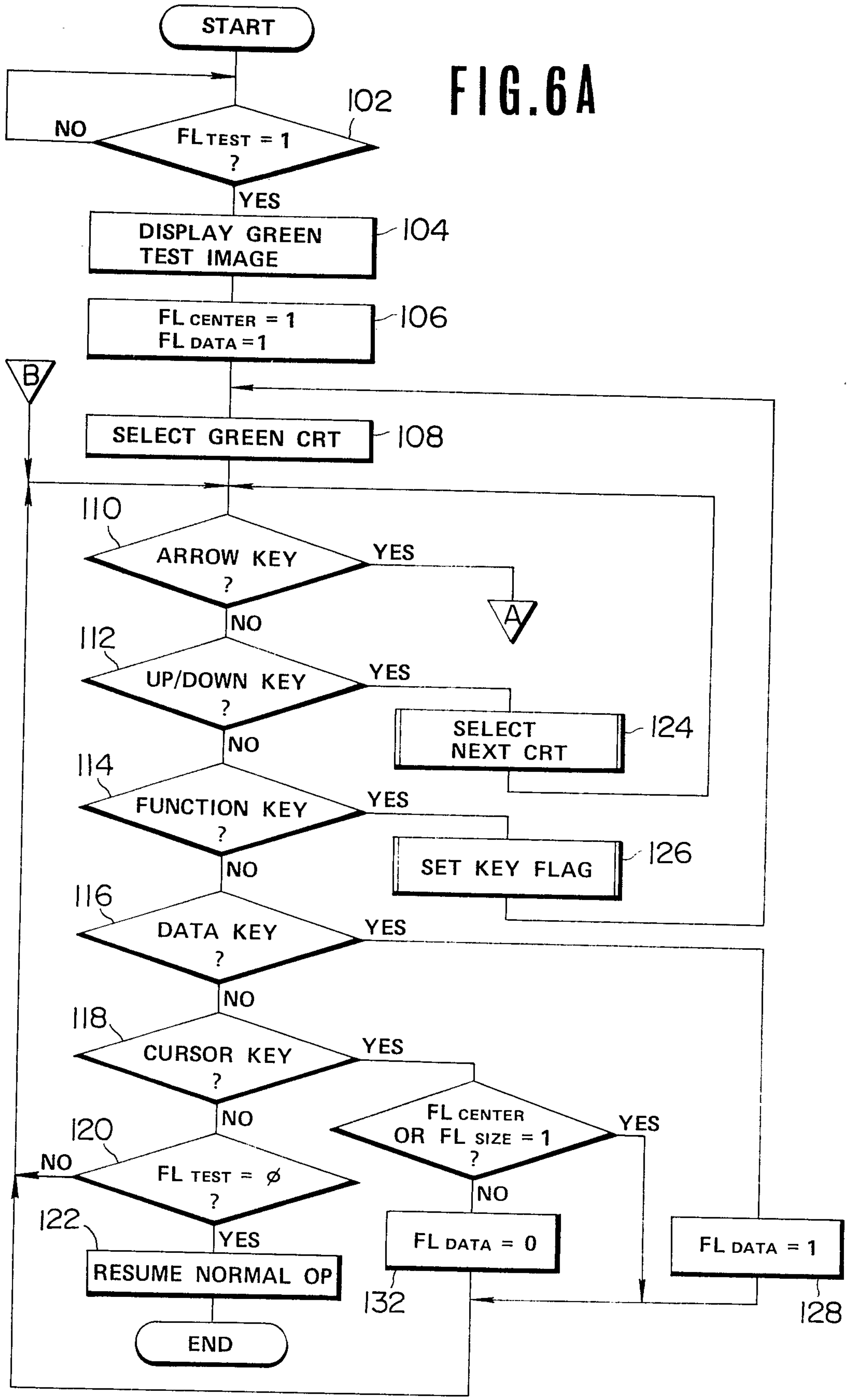
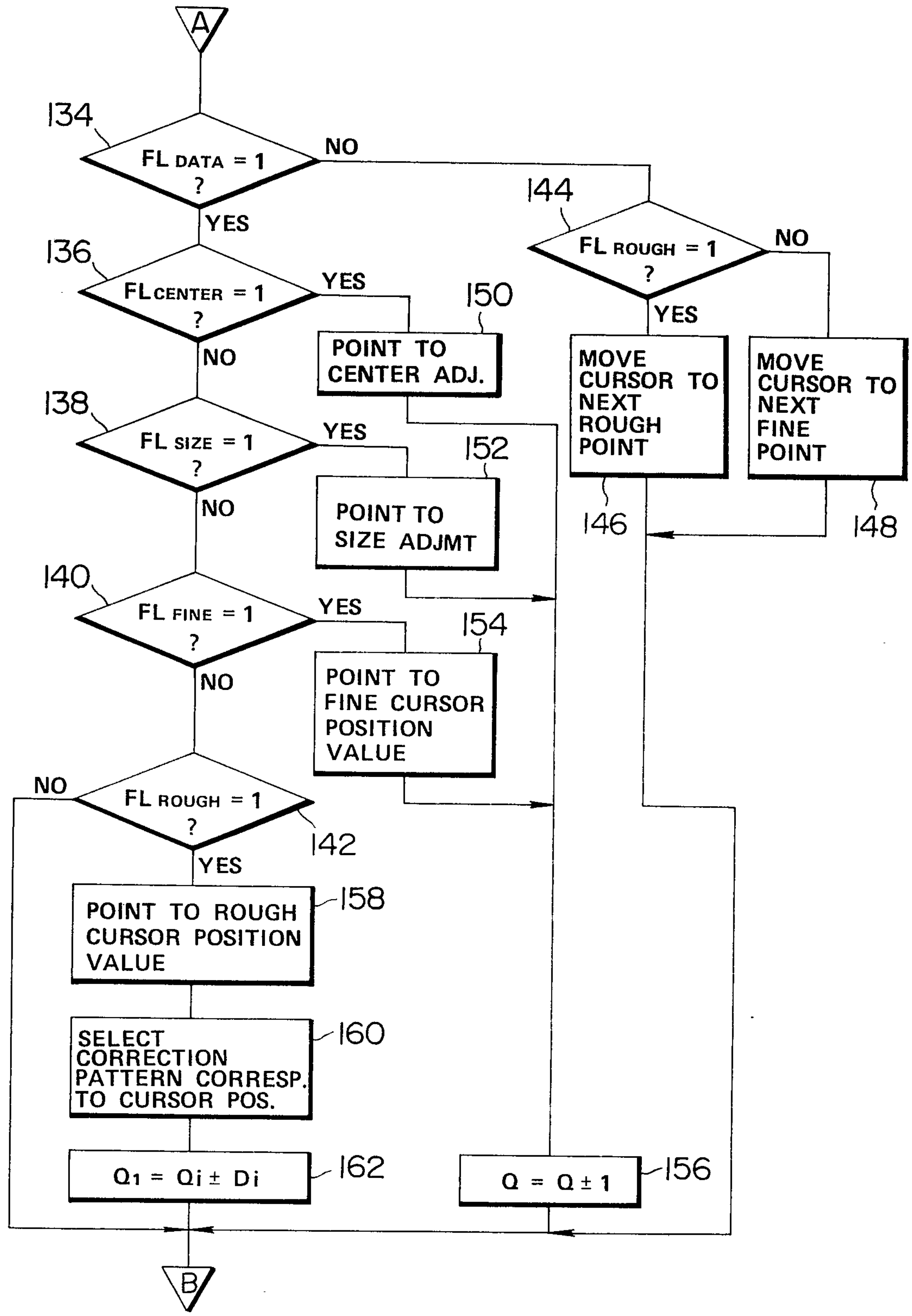


FIG.6A



START
102
FL TEST = 1 ?
NO
YES
DISPLAY GREEN TEST IMAGE
104
FL CENTER = 1
FL DATA = 1
106
B
SELECT GREEN CRT
108
110
ARROW KEY ?
YES
A
NO
112
UP/DOWN KEY ?
YES
SELECT NEXT CRT
124
NO
114
FUNCTION KEY ?
YES
SET KEY FLAG
126
NO
116
DATA KEY ?
YES
NO
118
CURSOR KEY ?
YES
FL CENTER OR FL SIZE = 1 ?
YES
NO
FL DATA = 0
132
FL DATA = 1
128
120
FL TEST = ø ?
NO
YES
122
RESUME NORMAL OP
END

FIG.6B



A
134
FL DATA = 1 ?
NO
YES
136
FL CENTER = 1 ?
YES
NO
150
POINT TO CENTER ADJ.
138
FL SIZE = 1 ?
YES
NO
152
POINT TO SIZE ADJMT
140
FL FINE = 1 ?
YES
NO
154
POINT TO FINE CURSOR POSITION VALUE
FL ROUGH = 1 ?
NO
YES
142
POINT TO ROUGH CURSOR POSITION VALUE
158
SELECT CORRECTION PATTERN CORRESP. TO CURSOR POS.
160
Q1 = Qi ± Di
162
144
FL ROUGH = 1 ?
NO
YES
MOVE CURSOR TO NEXT ROUGH POINT
146
MOVE CURSOR TO NEXT FINE POINT
148
Q = Q ± 1
156
B

SPECIFICATION

Establishing convergence of plural images on screens

This invention relates to processes and apparatus for establishing convergence of a plurality of images on a screen of a television monitor, for instance a colour television set, such as a projector-type television set.

The image on a screen of a colour television monitor is a composite of separate images (for example, red, green and blue images) that must accurately be superimposed or "converged" with respect to one another. Usually, a convergence correction signal is derived from analog processing of the horizontal and vertical deflection signals. Such correction processes generally fail to produce sufficient accuracy. Especially in the case of tricolour projector-type television sets, the accuracy of convergence correction achieved by previously proposed processes is insufficient, since even a slight misregistration of the individual images degrades noticeably the composite image produced by such projector-type television sets. In cases where the television image is formed on a generally planar screen, the distance between the colour television projector and various points on the screen varies as a function of displacement of the points from the optical axis of the projector. If the screen is large, for example about 1270 mm (50 inches) or larger, or uneven, or if the television set has a high definition or resolution (for example if the number of horizontal scan lines is around twice that of conventional systems), the inaccuracy of the previously proposed convergence correction processes has a particularly adverse effect on the quality of the image.

Digital techniques for correcting convergence have been developed in an attempt to eliminate the aforementioned defect in the known processes, which are analog processes. One digital convergence correcting process for a colour television set is disclosed, for example, in Japanese Patent Application First Publication No. JP-A-58-215887. The apparatus disclosed therein employs a test image or pattern, such as a dot pattern or cross-hatch pattern. The test pattern is reproduced on a television screen for convergence correction. Each dot or intersection of the test pattern is taken as an adjustment point. The correction needed at each adjustment point is derived as digital correction data. The corrections for all of the adjustment points for a given picture are are stored in a memory as digital correction data. The stored correction data for each adjustment point are read out synchronously with the beam scan on the screen. The digital correction data are converted into an analog signal indicative of the correction. The converted analog correction signal is supplied to a deflecting means that physically performs the convergence correction. This system allows the convergence to be corrected at each of the adjustment points.

In the above-described digital process for correcting convergence in a colour television set, the number of adjustment points determines the accuracy of the adjustment. Thus, to increase the adjustment accuracy it is necessary to increase the number of adjustment points and the number of separate adjustments. Naturally, this prolongs the time needed for adjustment. In addition, the adjustment is complex and requires a high level of skill found only in trained technicians. Further, individual tastes may still be dissatisfied with the image on the screen despite the most accurate possible objective adjustment. For these reasons, it is desirable that some provision be made for relatively easy adjustment of the convergence by relatively unskilled end users of the equipment.

The present invention provides a process for establishing convergence of a plurality of images on a screen of a television monitor, the process comprising:

forming on the screen a reference image that includes a plurality of reference points;

superimposing on the reference image a test image that is similar to the reference image, the test image including a plurality of adjustment points respectively corresponding to said reference points and including at least one correction portion corresponding to a given portion of the reference image, the correction portion including a given subset of said adjustment points;

selecting an adjustment point within said subset;

adjusting the position of said selected adjustment point with respect to the reference point corresponding thereto; and

simultaneously and proportionally adjusting the positions of the other points within said correction portion, thereby effecting establishment of a substantial covergence of said correction portion with respect to said given portion of the reference image.

The present invention also provides apparatus for establishing convergence of a plurality of images on a screen of a television monitor, the apparatus comprising:

reference means for forming on the screen a reference image that includes a plurality of reference points;

superimposing means for superimposing on the reference image a test image that is similar to the reference image, the test image including a plurality of adjustment points respectively corresponding to said reference points and including at least one correction portion corresponding to a given portion of the reference image, said correction portion including a given subset of said adjustment points; and

selection and adjustment means operable in a rough mode for selecting a given adjustment point with said subset, adjusting the position of said given adjustment point with respect to the reference point corresponding thereto, and simultaneously and proportionally adjusting the positions of the other points within said correction portion, thereby effecting establishment of substantial convergence of said correction portion with respect to said given portion of the reference image.

A preferred embodiment of the present invention described in detail hereinbelow provides a correction process and apparatus for convergence correction that provides high accuracy in a simple and quick adjusting operation, and provides for easy and arbitrary adjustments by an end user.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which like references designate like parts throughout, and in which:

Figure 1 is a block diagram of a convergence correcting apparatus forming a preferred embodiment of the present invention;

Figure 2 is a schematic illustration of a keyboard employed in the apparatus of Fig. 1;

Figure 3 is a diagram of a test image (test pattern) formed on a screen of a television monitor and employed in convergence correction performed by the apparatus of Fig. 1;

Figures 4A to 4H are diagrams showing various examples of substantial convergence correction performed by the apparatus of Fig. 1 with reference to various patterns of image distortion;

Figures 5A to 5H are diagrams showing various pattern data related to the corrections to test images shown in Fig. 4A to 4H; and

Figures 6A and 6B together form a flowchart of a program executed during a convergence correction process embodying the present invention.

In performing convergence correction according to the preferred embodiment of the present invention now to be described, one or more large-scale or rough correction patterns are employed in addition to the fine correction data for individual adjustment points used in the prior proposals described above. The extent of adjustment performed with reference to the correction patterns is displayed in real time on a test image on the screen. Practical convergence correction is thus performed on the basis of both the correction pattern and the correction data with respect to individual adjustment points.

By employing pattern correction for substantially correct convergence of the television monitor, convergence correction can be performed conveniently. In addition, since the human perception of deformation or distortion of the screen image concerns an area of the screen rather than individual screen points, large-scale correction may be sufficient.

Fig. 1 shows a preferred embodiment of convergence correcting apparatus according to the present invention. The apparatus includes a random-access memory (RAM) 1 having a plurality of addresses, each of which is arranged to store an item of digital convergence correction data (hereinafter referred to as "correction data") for a corresponding adjustment point on a television screen. Each item of correction data comprises 8 bits, and each storage location or cell in the RAM 1 thus is arranged to store an 8-bit byte. The RAM 1 is large enough to store correction data for all of a plurality of adjustment points of one full screen.

The RAM 1 is connected to an address bus 2. The address bus 2 is bidirectional and operable in both read and write modes. The address bus 2 is connected to a switching circuit 4 that is capable of switching the address bus between the read mode and the write mode. The RAM 1 also is connected to a bidirectional data bus 3 that operates in either the read mode or the write mode. The data bus 3 is connected in turn to a switching circuit 5 that controls the operational mode thereof. Both of the switching circuits 4 and 5 are connected by a line Sa to receive an input from a central processing unit (CPU) 8. The CPU 8 produces on the line Sa a read/write control signal hereinafter referred to as a "mode signal". The mode signal on the line Sa is either HIGH or LOW, as are all the other binary signals mentioned herein.

In this preferred embodiment, the switching circuit 4 responds to a LOW signal on the line Sa by switching the address bus 2 to the read mode. In the read mode, the switching circuit 4 connects an input A thereof to an output C thereof. The input A is connected to receive an input from an address encoder 7 that is connected in turn to an input terminal 6 that receives a horizontal synchronising signal P_H defining scan line timing on the television screen. The encoder 7 generates a read-address signal indicative of the next cell in the memory 1 for retrieval of the stored correction data. The encoder 7 adjusts the timing of the read-address signal in accordance with the synchronising signal P_H. The switching circuit 4 has another input B that is connected to receive an input from the CPU 8. The CPU 8 generates a write-address signal indicative of the address in the RAM 1 at which correction data is to be stored. The input B is connected to the output C when a HIGH level mode signal is supplied on the line Sa to the switching circuit 4.

Similarly, the switching circuit 5 has three terminals A', B', and C'. The terminal C' is connected to receive an input from the RAM 1 via the data bus 3. The terminal A' is connected to supply an output to an interpolation circuit 16. The interpolation circuit 16 may be of a type disclosed in US Patent No. US-A-4 305 022. The terminal B' is connected for input of correction data from the CPU 8. The switching circuit 5 responds to a LOW-level mode signal on the line Sa by connecting the terminals C' and A' so as to supply the read correction data to the interpolation circuit 16. On the other hand, the switching circuit 5 responds to a HIGH-level mode signal on the line Sa by connecting the terminals C' and B' so as to pass the correction data from the CPU 8 to the RAM 1 for storage.

The CPU 8 controls the read/write timing of the RAM 1 in a manner well known per se. For instance, the correction data is stored during the vertical blanking period. Therefore, the CPU 8 generates the HIGH-level mode signal in synchronism with the vertical blanking signal.

The CPU 8 is connected also to receive an input from a keyboard 10 through an input/output interface or port 9. As shown in Fig. 2, the keyboard 10 has function mode selector keys CENTER, SIZE, ROUGH and FINE which allow a user to select a corresponding function mode. The keyboard 10 also has UP and DOWN keys 41 and 42 used to select a cathode ray tube (CRT) of the television monitor for which correction or adjustment of convergence is to be performed. In practice, when the UP key 41 is depressed, the selection of the colour gun changes in the order green CRT-red CRT-blue CRT; and when the DOWN key 42 is depressed, the colour gun selection changes in the opposite order, i.e. blue CRT-red CRT-green CRT. The keyboard 10 also has a DATA key 43 which is used to enter an adjusting (correcting) mode, a CURSOR key 44 for forming a cursor on the screen and enabling the cursor to be moved by operating any of four cursor control or arrow keys 45*u*, 45*d*, 45*r* and 45*l* (hereinafter sometimes referred to collectively as the keys 45 or the arrow keys 45), and a TEST key that causes a test image or pattern to appear on the screen. The arrow keys 45 each represent a different direction of cursor movement on the screen. The respective directions are indicated by respective arrows on the keys. The distance through which the cursor moves is preferably proportional to the duration of depression of a given key. Alternatively, the distance through which the cursor moves may be proportional to the number of times the key is depressed. Both keyboards in which the magnitude of cursor movement is determined by the number of times the arrow key is depressed and keyboards in which arrow keys incorporate a repeat function, so that the effect of the keys is multiplied in accordance with the length of the time during which they are held depressed, are well known *per se*.

In the read mode, the interpolation circuit 16 (Fig. 1) receives the read correction data for each adjustment point on the screen. The interpolation circuit 16 derives correction values for a predetermined proportion (for example every other line) of the screen scan lines between two neighbouring adjustment points on the basis of the correction data of such two adjustment points. The interpolation circuit 16 sends the resultant interpolated correction data, together with the correction data for the two adjustment points, to a digital-to-analog (D/A) converter 17. The digital correction data is converted into analog correction signals in the D/A converter 17. The analog correction signals are supplied as an output through a low-pass filter (LPF) 18 and an output terminal 19. The output terminal 19 is connected to electromagnetic deflecting means (not shown) that performs convergence correction according to correction data supplied via the output terminal 19. As those skilled in screen scan techniques will appreciate, the LPF 18 comprises an interpolation filter for the horizontal direction.

In a tricolour tube projector-type television set, one convergence correction signal generating circuit comprising a RAM 1, switching circuits 4 and 5, an interpolation circuit 16, a D/A converter 17, and an LPF 18 is provided for convergence correction of the horizontal components of each of three colour Braun tubes or cathode-ray tubes (CRTs) employed in the television set, and another such convergence correction signal generating circuit is provided for convergence correction of the vertical components of each of the three CRTs. Therefore, a total of six convergence correction signal generating circuits are employed in a tricolour tube projector-type television set: two for the green CRT, another two for the red CRT, and another two for the blue CRT. Only one such circuit is shown in Fig. 1, since the other five circuits are identical thereto.

In this preferred embodiment, a rought (coarse) or "substantial correction" mode is established by operating the function mode selector key ROUGH (Fig. 2). Substantial correction is performed in the rough correction mode by reference to a correction pattern. The correction pattern is determined in a preliminary step by dividing the screen area into halves or quarters about the vertical and/or horizontal centre lines of the television screen. A fine correction mode is established by operating the function mode selector key FINE. in the fine correction mode, adjustment or correction of convergence is performed for each of the adjustment points individually. Similarly, a centring mode is established by operating the function mode selector key CENTER, and a size adjustment mode is established by operating the function mode selector key SIZE.

Both the rough or substantial correction and the fine correction are performed by reference to a predetermined test image or pattern. Fig. 3 shows one example of a test image that can be employed.

As Fig. 3 shows, the exemplary test image, which is generated electronically and displayed on the screen of the television monitor, is cross hatched and comprises 11 vertical lines and 11 horizontal lines. Each vertical and horizontal line is separated from the adjacent vertical or horizontal line or lines by a given uniform distance, and the lines in each of the two directions are respectively parallel to one another. Each intersection of a vertical and a horizontal line defines an adjustment point for fine correction of the convergence. Alternate vertical lines A, B, C, D and E and alternate horizontal lines a, b, c, d and e are used also for rough or substantial correction. Every intersection of the lines A, B, C, D and E and a, b, c, d, e thus defines an adjustment point for rough or substantial correction. Therefore, in the rough correction mode, the cursor 51 can be positioned only at one of the respective intersections of the lines A, B, C, D, E and a, b, c, d, e. In Fig. 3, the illustrated positions of the cursor 51 indicate all of the possible adjustment points that can be used for rough correction. (Of course, while (in the rough mode) the cursor can occupy any of the twenty-five positions 51 shown in Fig. 3, it occupies only one such position at a time). A chain-dotted or phantom line 50 in Fig. 3 outlines one predetermined picture area of the television screen. Of the entire set of 25 adjustment points available in the rough mode, various subsets are selected for adjustment as explained below.

The RAM 1 has a capacity at least large enough to accommodate correction data relating to all of the adjustment points for fine correction. To accommodate correction data relating to the adjustment points shown in Fig. 3, the RAM 1 requires at least 11×11=121 addresses. Each address stores correction data for a corresponding adjustment point in the form of an 8-bit two's complement code.

In order to generate the test image, a test image generating circuit 35 (Fig. 1) is connected to receive an input from the CPU 8 through an input/output interface or port 34. The test image generating circuit 35 generates a serial test signal representing the two-dimensional test image 52 (Fig. 3) on the television screen. The test signal from the test image generating circuit 35 first passes through a mixer 36 (Fig. 1). The CPU 8 is connected also to supply an output to a cursor signal generating circuit 38 through an input/output interface or port 37. The cursor signal generating circuit 38 derives a cursor position based on direction and distance inputs from the arrow keys 45 (Fig. 2). The cursor signal generating circuit 38 (Fig. 1) produces a cursor signal representative of the position of the cursor 51 (Fig. 3) on the television screen. The cursor signal generating circuit 38 supplies the cursor signal to the mixer 36 (Fig. 1).

The mixer 36 generates a video signal by combining the test signal from the test image generating circuit 35 and the cursor signal from the cursor signal generating circuit 38. The video signal is supplied as an output to the CRT via an output terminal 39.

The CPU 8 is connected also to receive an input from a plurality of read-only memories (ROMs) 21 to 28. Each ROM 21 to 28 holds correction pattern data indicative of one or a plurality of patterns for convergence correction. The ROMs 21 to 28 generate outputs that are supplied as respective inputs to the CPU 8 through a data bus. The correction pattern data read from each of the ROMs 21 to 28 is modified by the CPU 8 by multiplying it by a given correction coefficient. The correction coefficient is determined by a linar or hyperbolic curve approximating method, known *per se*. The modified correction pattern data is added to or subtracted from the correction data read from the RAM 1.

Figs. 4A to 4H and 5A to 5H illustrate a process of convergence correction using correction pattern data generated by the apparatus described with reference to Figs. 1 to 3. Eight corrections are illustrated in Figs. 4A to 4H, respectively. The same eight corrections are illustrated in Figs. 5A to 5H, respectively, and the eight corrections illustrated in Figs. 4A to 4H correspond, respectively, to the eight corrections illustrated in Figs. 5A to 5H. In Fig. 4A to 4H, the solid lines represent a distorted test image as displayed initially on the screen and the broken lines represent the test image after adjustment. The hatched square 51 represents the cursor and the areas hatched in phantom represent respective correction portions of the screen affected by convergence correction adjustments. As the figures show, the correction portions are to some extent overlapping.

Figs. 4A and 5A show one way to correct the convergence over one quarter of the screen area near one corner of the screen. In this example, convergence correction is effected in the lower, left hand quarter of the screen area, namely the area hatched in phantom in Fig. 4A. To effect the convergence correction shown in Fig. 4A, the cursor 51 is positioned at the adjustment point at the intersection of the vertical line A and the horizontal line e. (In the following disclosure, the adjustment points are identified by the vertical and horizontal lines that intersect respectively at the adjustment points. Thus, the adjustment point just mentioned is identified as the adjustment point Ae). The correction portion, indicated by the phantom hatch lines, includes the subset of four adjustment points Ae, Ad, Bd, Be of the entire set of 25 "rough" adjustment points. In the rough or coarse correction mode, the active adjustment point during a given correction process is the one that corresponds to the position of the cursor 51. Therefore, by moving the cursor 51 to the lower left hand corner position as illustrated in Fig. 4A, the adjustment point Ae is selected automatically. Selection of the adjustment point Ae implies selection also of the adjustment points Ad, Bd and Be, so that these points also will be adjusted by a predetermined proportion of the correction applied to the cursor-selected adjustment point Ae. The positions of the fine adjustment points and, indeed, of all of the points within the correction portion, are adjusted simultaneously and proportionally.

In the present example (Fig. 4A), the rightward arrow key 45*r* (Fig. 2) is operated to move the cursor 51, together with the adjustment point Ae, horizontally to the right until the cursor 51 reaches the imaginary vertical straight line A (Fig. 4A). Thereafter, the upward arrow key 45*u* (Fig. 2) is operated to move the cursor 51, together with the adjustment point Ae, upwardly along the vertical line A until the cursor 51 reaches the desired corner position, i.e. until it reaches the subjectively straight horizontal line e. Of course, the arrow keys 45*r* and 45*u* can be operated in either order, and if an adjustment is carried too far in one direction, the cursor 51 can be moved in the reverse direction by means of the leftward or downward arrow key 45*l* or 45*d*, as may be required. In short, the various arrow keys 45 can be operated repeatedly in any sequence until the desired adjustment has been made. Moreover, to correct certain distortions, one may begin with the keys 45*l* and 45*d*.

In Fig. 5A, the magnitude of the correction, that is the extent of the positional adjustment of the adjustment point Ae from its initial position, is illustrated in terms of displacement along a third coordinate axis. This correction pattern can be used for convergence correction at any of the corners Aa, Ea and Ee as well as Ae.

Figs. 4B and 5B illustrate a second type of rough or substantial convergence correction. In this case convergence is corrected over half of the screen area and predominantly along an edge thereof. In the example, the left hand side of the screen is distorted. In order substantially to correct this, the cursor 51 is positioned at the adjustment point Ac midway along the edge to be adjusted. In this case, the right-hand arrow key 45*r* and the downward arrow key 45*d* are operated in any order until the cursor 51 reaches the proper position of the adjustment point Ac illustrated by the intersections of the broken lines A and c. The movement of the adjustment point Ac together with the cursor 51 effects movement of nine other adjustment points, namely Aa, Ab, Ad, Ae, Ba, Bb, Bc, Bd and Be. These points all are shifted in substantially the same direction as the direction in which the adjustment point Ac is shifted. The points Aa, Ab, Ad and Ae are shifted by a distance substantially equal to the distance through which the point Ac is shifted, while the points Ba, Bb, Bc, Bd and Be are shifted through a distance less than but proportional to the distance through which the adjustment point Ac is shifted. To correct certain distortions, the keys 45*l* and 45*u* may be employed.

Those skilled in the art will understand that, in order to correct the convergence on the right half of the screen area, the cursor 51 is placed at the adjustment point Ec.

Figs. 4C and 5C show a third kind of correction pattern. This third correction pattern is similar to that shown in Figs. 4B and 5B, but is used for convergence correction in the upper and lower halves of the screen. In this case, the cursor 51 is placed over the adjustment point Ca. During rough or substantial correction, the adjustment point Ca shifts in the direction and through the distance specified by the arrow keys 45. In the example, the left hand arrow key 45*l* and the downward arrow key 45*d* are operated so that the cursor 51 moves to the correct position illustrated by the intersection of the broken lines C and a. The nine adjustment points Aa, Ab, Ba, Bb, Cb, Da, Db, Ea and Eb are shifted automatically by this adjustment, in substantially the same direction as the direction in which the point Ca is shifted. The points Aa, Ba, Da and Ea are shifted by a distance substantially equal to the distance through which the point Ca is shifted, while the points Ab, Bb, Cb, Db and Eb are shifted through a distance less than but proportional to the distance through which the point Ca is shifted. This brings all of these points to the subjectively correct positions indicated by the respective intersections of the broken lines. To correct certain distortions, the keys 45*r* and 45*u* may be employed.

Of course, when the lower half of the screen area is to be corrected, the cursor 51 is placed over the adjustment point Ce. Otherwise, the process is the same as for correction of the upper half of the screen area.

The three correction patterns discussed above are principal correction patterns for normal use. Because of the nature of common beam deflection errors, the five correction patterns discussed below with reference to Figs. 4D to 4H and 5D to 5H will be used much less frequently. The previously discussed patterns correct distortion at a corner or along an edge of the screen, where the greatest deviations from symmetry both horizontally and vertically occur. In the following cases, the distortion occurs either about a point on the screen or along a line parallel to and within the edges of the screen.

Figs. 4D and 5D show a fourth correction pattern, which is used when convergence correction concerns only a quarter of the screen area and is centred about an adjustment point at the centre of a screen quadrant. In this case, the cursor 51 is moved together with the adjustment point Bd to the correct position by operation of the rightward arrow key 45*r* and the upward arrow key 45*u*. As those skilled in the art will understand, to correct other distortions, the keys

45*l* and 45*d* may be employed.

For similar correction of the other quadrants of the screen, the cursor 51 is placed over the corresponding centre adjustment points Bb, Db and Dd.

Figs. 4E and 5E show a fifth correction pattern, which is used when the vertical line B between the vertical edge A and the vertical centreline C is distorted vertically and/or horizontally. In order to perform this type of convergence correction, the cursor 51 is placed over the adjustment point Bc. Then, the rightward arrow key 45*r* and the downward arrow key 45*d* are operated so as to move the cursor 51 and the adjustment point Bc to the correct position shown in Fig. 4E by the intersection of the broken line B and c. The adjustment points Ba, Bb, Bd and Be on the vertical line B are shifted substantially in the same direction and substantially to the same extent as the adjustment point Bc. As those skilled in the art will understand, to correct certain other distortions, the keys 45*l* and 45*u* may be employed.

When this convergence correction is to be applied to the vertical line D, the cursor 51 is of course placed at the adjustment point Dc.

Figs. 4F and 5F show a sixth correction pattern, which is used to correct vertical and/or horizontal offset of the horizontal lines b and d between the horizontal edges a and e and the horizontal centreline c. This correction is similar to that discussed above with reference to Figs. 4E and 5E. In Figs. 4F and 5F, convergence along the horizontal line b is to be corrected. The rightward arrow key 45*r* and the downward arrow key 45*d* are operated to shift the adjustment point Cb to the correct position indicated by the intersection of the broken lines C and b. All of the other adjustment points along the horizontal line b shift in the same direction and to the same extent to their respective correct positions shown by the respective intersections of the broken lines A, B, D and E with the horizontal broken line b. Of course, to correct certain other distortions, the keys 45*l* and 45*u* may be employed.

Figs. 4G and 5G show a seventh correction pattern, which is used to correct offset of an adjustment point (such as Ad) located along a vertical edge without affecting the horizontal edges or the horizontal centreline. Analogously to the preceding examples, the cursor 51 is first positioned over the adjustment point Ad. Then, it is moved together with the adjustment point Ad to the correct position shown by the intersection of the broken lines A and d by operating the rightward arrow key 45*r* and the upward arrow key 45*u*. To correct certain other distortions, the keys 45*l* and 45*d* may be employed.

When the seventh correction pattern is to be applied to another quadrant, the cursor 51 is placed over the corresponding adjustment point Ab, Eb or Ed.

Figs. 4H and 5H show the eighth correction pattern, which is similar to the seventh pattern. The convergence about an adjustment point such a the point Ba, located on a horizontal edge a or e and on one of the vertical lines B or D between the vertical edge A or E and the vertical centreline C, is corrected without affecting the adjoining vertical edge or the vertical centreline. In the example illustrated, the cursor 51 is placed over the adjustment point Ba. The rightward arrow key 45*r* and the downward arrow key 45*d* are operated to move the adjustment point Ba to the right and downwardly to the correct position. Of course, to correct certain other distortions, the keys 45*l* and 45*u* may be employed.

From the preceding description, it can be seen that an operator of the apparatus makes corrections in the rough mode as shown in the following table:

TABLE

KEY	FUNCTION
TEST Key	Green test pattern appears. Centring correction mode selected.
Arrow Keys 45	Raster centre of green, red and blue test patterns simultaneously corrected. Raster moved in accordance with arrow directions.
SIZE Key	Size correction mode selected.
Arrow Keys 45	Raster size for green, red and blue test patterns simultaneously corrected. Right arrow enlarges horizontal dimension; left arrow contracts it. Up arrow enlarges vertical dimension; down arrow contracts it.
Key 41	Green and Red test patterns appear.
ROUGH Key	Rough convergence mode selected.
Key 44	Cursor moving mode selected. Cursor reappears at centre reference point.
Arrow Keys 45	Cursor moves to selected intersection.
Data Key 43	Cursor locks on.
Arrow Keys 45	Red distortion corrected in selected segment so that red pattern is coincident with green pattern. (Jump to fourth step below when all distortion has been corrected).
Key 44	Cursor moving mode selected. Cursor reappears at former reference point.
Arrow Keys 45	Cursor moves to next selected intersection.
Data Key 43	Cursor locks on (Jump to third step above and repeat as necessary for other screen areas).
Key 41	Green and Blue test patterns appear.
ROUGH Key	Rough Convergence mode selected.
Key 44	Cursor moving mode selected. Cursor reappears at centre reference point.
Arrow Keys 45	Cursor moves to selected intersection.
Data Key 43	Cursor locks on.
Arrow Keys 45	Blue distortion corrected in selected segment so that blue pattern is coincident with green (and red) patterns. (Jump to fourth step below when all distortion has been corrected).
Key 44	Cursor moving mode selected. Cursor reappears at former reference point.
Arrow Keys 45	Cursor move to next selected intersection.
Data Key 43	Cursor locks on. (Jump to third step above and repeat as necessary for other screen areas).
Test Key	Resume normal operations.

The overall convergence control operation performed by the preferred apparatus is described below with reference to a program illustrated in flow chart form in Figs. 6A and 6B. In order to enter a test mode, the TEST key (Fig. 2) is depressed. If the TEST key is not depressed, the television set does not enter the test mode and thus operates in its normal mode. To check for operation of the TEST key, a test mode indicator flag FL_{TEST} in a flag register 53 (Fig. 1) is checked at a step 102 (Fig. 6A), immediately after the start of execution of the program. If the test mode indicator flag FL_{TEST} is not set when checked at the step 102, then the program loops until the TEST key is depressed, and the television set remains in its normal operating state. After the TEST key is depressed and the test mode indicator flag FL_{TEST} thus is set in the flag register 53, a test pattern such as the one shown in Figs. 4A to 4H is generated electronically and displayed on the television screen at a step 104. Thereafter, initialisation is performed at a step 106, which includes setting the centring mode and data mode. At a step 108, an initial CRT (for example the green CRT) is selected and set. At the next step 110, the arrow keys 45 are checked to see whether any of them has been operated.

If no arrow keys 45 have been operated when checked at the step 110, the UP key 41 and the DOWN key 42 are checked for depression at a step 112. If neither the UP key 41 nor the DOWN key 42 has been operated, then, at a step 114, the function keys CENTER, SIZE, ROUGH and FINE are checked for depression. If none of the function keys has been operated when checked at the step 114, the DATA key 43 is checked for depression at a step 116. If it is determined at the step 116 that the DATA key 43 has not been depressed, the CURSOR key 44 is checked for depression at a step 118. If the CURSOR key 44 has not been operated when checked at the step 118, then the TEST key is checked again for depression at a step 120. If the TEST key has not been depressed, the program loops back to the step 110. On the other hand, if the TEST key has again been depressed when checked at the step 120, then the television set leaves the test mode, and an input video signal (for example a broadcast signal) is processed to produce a display on the screen as normal operation of the television set resumes. This is represented at a step 122.

If either the UP key 41 (Fig. 2) or the DOWN key 42 is depressed when checked at the step 112 (Fig. 6A), the next colour CRT for which convergence correction is to be performed is switched in at a step 124. It is within the scope of the invention that, when convergence correction is to be performed for the green CRT, the test images for the red CRT and the blue CRT are formed also on the screen together with the test image for the green CRT; when convergence correction is to be performed for the blue CRT, the test images for the red and green CRTs are formed on the screen together with the test image for the blue CRT; and, when convergence correction is to be performed for the blue CRT, the test images for the red CRT and the green CRT are formed on the screen together with the test image for the blue CRT. Each time that the UP mode selector key 41 (Fig. 2) is depressed, the CRT for which convergence control is to be performed is switched in the order green-red-blue. Each time that the DOWN mode selector key 42 is depressed, the CRT for which convergence control is to be performed is switched in the reverse order: that is blue-red-green. After CRT selection in the block 124 (Fig. 6A), the program returns to the step 110.

If any of the function keys CENTER, SIZE, ROUGH or FINE (Fig. 2) is depressed when checked at the step 114 (Fig. 6A), a flag FL_{CENTER}, FL_{SIZE}, FL_{ROUGH} or FL_{FINE} (Fig. 1) indicative of the selected function mode is set in a corresponding flag register 54, 55, 56 or 58 at a step 126 (Fig. 6A). After the flag FL_{CENTER}, FL_{SIZE}, FL_{ROUGH} or FL_{FINE} corresponding to the depressed mode function key is set, the program returns to the step 108.

When depression of the DATA key 43 (Fig. 2) is detected upon checking at the step 116 (Fig. 6A), a data mode indicative flag FL_{DATA} (Fig. 1) is set in a flag register 60 at a step 128 (Fig. 6A) and then the program returns to the step 110. When depression of the CURSOR key 44 (Fig. 2) is detected at the step 118 (Fig. 6A), then the flags FL_{CENTER} and FL_{SIZE} (Fig. 1) are checked at a step 130 (Fig. 6A) to see if they are set. If either the flag FL_{CENTER} or the flag FL_{SIZE} is set, then the program returns to the step 110. On the other hand, if neither the flag FL_{CENTER} nor the flag FL_{SIZE} is set when checked at the step 130, then the cursor mode is set at a step 132 and the program returns to the step 110.

When one of the arrow keys 45 (Fig. 2) is depressed and depression of the depressed arrow key 45 is detected at the step 110 (Fig. 6A), the data mode indicative flag FL_{DATA} (Fig. 1) is checked at a step 134 (Fig. 6B). If the data mode indicative flag FL_{DATA} is set when checked at the step 134, then the flag FL_{CENTER} is checked at a step 136. If the flag FL_{CENTER} is not set when checked at the step 136, the flag FL_{SIZE} is checked at a step 138 to determine whether or not it is set. If the flag FL_{SIZE} is not set when checked at the step 138, the flag FL_{FINE} is checked at a step 140 to see if it is set. If the flag FL_{FINE} is not set when checked at the step 140, then the flag FL_{ROUGH} is checked at a step 142 to determine whether or not it is set. If the flag FL_{ROUGH} also is not set, then the program returns to the step 110 (Fig. 6A).

If the flag FL_{DATA} is not set when checked at the step 134 (Fig. 6B), then the flag FL_{ROUGH} is checked again at a step 144. If the flag FL_{ROUGH} is set, then, at a step 146, the cursor 51 is moved discontinuously (stepwise) in the direction or directions designated by the depressed arrow key or keys 45 to the next rough adjustment point, that is from one to another of the adjustment points defined by the respective intersections of the vertical and horizontal lines A, B, C, D, E and a, b, c, d, e (Figs. 3 to 5), so as to select one of the adjustment points for rough correction. This selection process also identifies one of the correction patterns shown in Figs. 4 and 5. On the other hand, if the flag FL_{ROUGH} is not set when checked at the step 144 (Fig. 6B), then, at a step 148, the cursor 51 is moved in the direction or directions designated by the depressed arrow key or keys 45 to the next fine adjustment point to identify the adjustment point at which fine correction is to be performed. Such movement is also discontinuous or stepwise, but is from one to another of the adjustment points defined by the respective intersections of all of the vertical and horizontal lines of Fig. 3. After execution of one of the blocks 146 and 148, the program returns to the step 110 (Fig. 6A).

If the centring mode indicator flag FL_{CENTER} is set when checked at the step 136 (Fig. 6B), a centring operation for the test pattern of the CRT selected at the step 108 or 124 (Fig. 6A), which CRT is sometimes referred to hereinafter as the "selected CRT", is performed at a step 150 (Fig. 6B). In the centring operation, the memory address of a deviation value of the test pattern centre of the selected CRT from the screen centre of the selected CRT is set in a memory pointer, as indicated at the step 150, for use later. Similarly, if the size adjusting mode indicator flag FL_{SIZE} is set when checked at the step 138, the memory address of a size adjustment value is set in a memory pointer as indicated at a step 152. The size adjustment value represents the deviation of the test pattern size of the selected CRT from the screen size of the selected CRT. If the fine correction mode indicative flag FL_{FINE} is set when checked at the step 140, then a memory address corresponding to the cursor position is identified, as indicated at a step 154. After any of the steps 150, 152 or 154, the data Q stored in the identified memory address is updated by adding or subtracting 1 to or from the stored data value Q at a step 156. In practice, if the depressed arrow key is 45*u* or 45*r*, the stored data value is incremented by 1, and if the depressed arrow key is 45*d* and 45*l*, then the stored data value is decremented by 1.

If the rough correction mode indicator flag FL_{ROUGH} is set when checked at the step 142, then the memory address corresponding to the cursor position is identified at a step 158. The correction pattern corresponding to the cursor position is selected at a step 160. After selecting the proper correction pattern, position data values Q_i for the cursor and all of the related adjustment points in the pattern are adjusted by corresponding values $\pm D_i$ at a step 162. The values D_i are predetermined for each of the correction patterns and each type of point in each pattern and may differ from those in other correction patterns. As in the step 156, when the depressed arrow key (Fig. 2) is 45*u* or 45*r*, the given value D_n is added to the stored value Q_n, and when the depressed arrow key is 45*d* or 45*l*, the stored data value Q_n is decremented by the given value D_n. After execution of either of steps 156 and 162, the program returns to the step 110 (Fig. 6A).

As long as the arrow key 45 is depressed, the steps 134 to 162 are repeatedly cyclically.

It will be seen that the preferred embodiment of the invention described above provides a highly effective convergence correction process and apparatus that provide high accuracy in a simple and quick adjusting operation, and that enable easy and arbitrary adjustments by an end user.

Many modifications of the preferred embodiment of the invention will occur to those skilled in the art upon consideration of the foregoing disclosure. For example, those skilled in the art will appreciate, in the light of the foregoing disclosure, that the number and kinds of correction patterns and the means of identifying the correction patterns that are used can all be varied within wide limits.

CLAIMS

1. A process for establishing convergence of a plurality of images on a screen of a television monitor, the process comprising;

forming on the screen a reference image that includes a plurality of reference points;

superimposing on the reference image a test image that is similar to the reference image, the test image including a plurality of adjustment points respectively corresponding to said reference points and including at least one correction portion corresponding to a given portion of the reference image, the correction portion including a given subset of said adjustment points;

selecting an adjustment point within said subset;

adjusting the position of said selected adjustment point with respect to the reference point corresponding thereto; and

simultaneously and proportionally adjusting the positions of the other points within said correction portion, thereby effecting establishment of a substantial convergence of said correction portion with respect to said given portion of the reference image.

2. A process according to claim 1, wherein said other points within said correction portion are moved in directions substantially parallel to the adjustment of said selected adjustment point.

3. A process according to claim 1, wherein said other points within said correction portion are moved through distances respectively equal to or less than the distance through which said selected adjustment point is moved.

4. A process according to claim 1, wherein the test image includes at least a second correction portion corresponding to a second portion of the reference image different from said given portion, said second correction portion including a second subset of said adjustment points different from said given subset, and wherein the process comprises:

selecting a second adjustment point within said second subset;

adjusting the position of said second adjustment point with respect to the reference point corresponding thereto; and

simultaneously and proportionally adjusting the positions of the other points within said second correction portion, thereby establishing a substantial convergence of said second correction portion with respect to said second portion of the reference image.

5. A process according to claim 1, wherein the test image includes a plurality of correction portions respectively corresponding to different portions of said reference image and including different subsets of said adjustment points, the process comprising determining, in dependence on said selection of one of said adjustment points, one of said correction portions the positions

of the other points of which are simultaneously and proportionally adjusted.

6. A process according to claim 1, wherein said selecting of an adjustment point comprises:
generating a cursor on the screen;
moving the cursor to a given adjustment point; and
locking the cursor onto the given adjustment point.

7. A process according to claim 1, wherein the reference image includes a plurality of additional reference points and the test image includes a plurality of additional adjustment points respectively corresponding to said additional reference points and wherein the method comprises:
selecting any of said adjustment points and additional adjustment points and adjusting the position thereof with respect to reference points respectively corresponding thereto without adjusting the positions of the other adjustment points and additional adjustment points; and
repeating for as many adjustment points and additional adjustment points as necessary to establish a fine convergence of the test image with respect to the reference image.

8. A process according to claim 7, wherein said selecting of any of said adjustment points and additional adjustment points and adjusting the position thereof to establish said fine convergence is effected after said establishment of said substantial convergence.

9. A process according to claim 1, wherein said selected adjustment point within said subset has an initial displacement with respect to the reference point corresponding thereto at least as great as the initial displacement of any of said other adjustment points within said subset with respect to the reference points respectively corresponding thereto.

10. A process according to claim 1, wherein the monitor comprises three beam-generating means and is capable of normal operation in which it displays colour television images on the screen, and wherein said forming of the reference image is by means of one of the beam-generating means and said superimposing of the test image is by means of another of the beam-generating means, the process comprising selecting any of the beam-generating means to form the reference image and either of the other of the beam-generating means to form the test image.

11. A process according to claim 10, comprising thereafter selecting the third of the beam-generating means to form the test image, thereby establishing a substantial convergence of corresponding portions of images respectively displayed by the three beam-generating means.

12. Apparatus for establishing convergence of a plurality of images on a screen of a television monitor, the apparatus comprising:
reference means for forming on the screen a reference image that includes a plurality of reference points;
superimposing means for superimposing on the reference image a test image that is similar to the reference image, the test image including a plurality of adjustment points respectively corresponding to said reference points and including at least one correction portion corresponding to a given portion of the reference image, said correction portion including a given subset of said adjustment points; and
selection and adjustment means operable in a rough mode for selecting a given adjustment point within said subset, adjusting the position of said given adjustment point with respect to the reference point corresponding thereto, and simultaneously and proportionally adjusting the positions of the other points within said correction portion, thereby effecting establishment of substantial convergence of said correction portion with respect to said given portion of the reference image.

13. Apparatus according to claim 12, wherein the test image includes a plurality of correction portions respectively corresponding to different portions of the reference image and including different subsets of said adjustment points, and selection of one of said adjustment points by the selection and adjustment means determines one of said correction portions the positions of the other points of which are simultaneously and proportionally adjusted by the selection and adjustment means, whereby sequential selection and adjustment of one of said adjustment points in each of a plurality of said correction portions establishes a rough convergence of the entirety of the test image with respect to the reference image.

14. Apparatus according to claim 13, wherein a plurality of said correction portions are in overlapping relation.

15. Apparatus according to claim 12, wherein the selection and adjustment means comprises means for generating a cursor on the screen, moving the cursor to a given adjustment point, and locking the cursor onto said given adjustment point.

16. Apparatus according to claim 12, wherein the reference image includes a plurality of additional reference points and the test image includes a plurality of additional test points respectively corresponding to said additional reference points, the apparatus comprising function means for controlling the selection and adjustment means as it operates selectively in a fine mode for:
selecting any of said adjustment points and additional adjustment points and adjusting the

position of said selected adjustment point or additional adjustment point without adjusting the positions of the other adjustment points and additional adjustment points; and

repeating for as many adjustment points and additional adjustment points as necessary to establish a fine convergence of the test image with respect to the reference image.

17. Apparatus according to claim 16, comprising random-access memory means having a separate memory address corresponding to each of said adjustment points and additional adjustment points and means for generating values respectively corresponding to the displacement of said adjustment points and additional adjustment points from said respective reference points, said values being stored in said respective memory addresses.

18. Apparatus according to claim 12, wherein a pair of the selection and adjustment means is provided, a first being operative to adjust the position of said given adjustment point in the vertical direction of the screen and the second being operative to adjust the position of said given adjustment point in the horizontal direction of the screen.

19. Apparatus according to claim 12, wherein the monitor comprises three beam-generating means and is capable of normal operation in which it displays colour television images on the screen, and wherein the reference means comprises one of the beam-generating means and the superimposing means comprises another of the beam-generating means, the apparatus comprising function means operative to select any of the beam-generating means to form the reference image and either of the other of the beam-generating means to form the test image.

20. Apparatus according to claim 19, wherein the function means is thereafter operative to select the third of the beam-generating means to form the test image, thereby establishing a substantial convergence of corresponding portions of images respectively displayed by the three beam-generating means.

21. Apparatus according to claim 20, wherein six of the selection and adjustment means are provided, a first three being operative to adjust the vertical positions of said given adjustment points of test images respectively formed by the three beam-generating means and a second three being operative to adjust the horizontal positions of said given adjustment points of the test images respectively formed by the three beam-generating means.

22. Apparatus according to claim 12, comprising means for centring the reference and test images on the screen.

23. Apparatus according to claim 12, comprising means for adjusting the size of the reference and test images.

24. Apparatus according to claim 12, comprising random-access memory means having a separate memory address corresponding to each of said adjustment points and means for generating values respectively corresponding to the displacements of said adjustment points from said respective reference points, said values being stored in said respective memory addresses.

25. A process for establishing convergence of a plurality of images on a screen of a television monitor, the process being substantially as herein described with reference to the accompanying drawings.

26. Apparatus for establishing convergence of a plurality of images on a screen of a television monitor, the apparatus being substantially as herein described with reference to the accompanying drawings.

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