The invention relates to a convergence adjustment device for a videoprojector having several cathode ray tubes.

A videoprojector is a television receiver projecting pictures onto a screen of larger dimensions than the usual screens of cathode ray tubes. The most usual type comprises three cathode ray tubes, one for each primary colour, and, for each of these tubes, an optical system for projection onto a screen. The images produced by the three tubes must be perfectly superimposed on the screen. This result is practically impossible to achieve by simple orientation adjustments of the tubes and of the optical systems for projection. There are various reasons for this impossibility: variations, inherent in mass production, of the shapes of images produced by each of the tubes; the lenses, usually in plastic material, which, for cost reasons, do not have chromatic corrections and which, thus, do not have the same refractive index for all three primary colours; the axes of the three tubes cannot all be perpendicular to the projection screen: in general the axis of the tube projecting the green image is in principle perpendicular to the screen and the axes of the tubes projecting the red and blue images are inclined in opposite directions with respect to this perpendicular; thus the green image may be rectangular whereas the red and blue images have a trapezium shape with parallel vertical edges.

This is why a videoprojector comprises a convergence correction or adjustment circuit which generates currents energising coils acting on the horizontal and vertical deviations of the electron beams from two of the tubes, in general the red and the blue, in order to shape the corresponding images so that they become superimposed, on the screen, with the image projected by the first tube, namely the green. This correction is made either directly onto the currents of the line (horizontal) deviation and frame (vertical) deviation coils with the use of active elements and modulators, or by means of auxiliary deviators.

Hitherto, in order to perform these convergence adjustments during installation of the videoprojector, use has generally been made of analog circuits with potentiometers which are adjusted so that

convergence correction signals are generated which are optionally variable from one zone to another of the picture.

An adjustment device of digital type is also known (patent US-A-3,943,279) which comprises a random access memory in which are stored correction values corresponding to corrections of the scan currents for the various zones into which the picture is divided, these values being restored into synchronism with the scanning of the zones during normal operation, and a computer means for modifying the stored values during the adjustment phase, depending on the commands issued by the user performing this adjustment zone by zone, or group of zones by group of zones, by observing the picture. The circuit of this patent is complicated to handle.

The circuit according to the invention is of digital type, being inexpensive while nevertheless enabling persons of no special skill to perform a large number of adjustments.

The device of the invention is, then, a convergence adjustment device for colour videoprojectors having three monochrome tubes each projecting an image of one given colour onto a screen, this device, of digital type, acting on the scanning of the second and third tubes so as to superimpose, on the screen, their images with that of the first tube and it comprises a random access memory in which are stored correction values corresponding to corrections of the scan currents for the various zones into which the picture is divided, these values being restored to synchronism with the scanning of the zones during normal operation, and a computer means for modifying the memorised values, during the adjustment phase, depending on the commands issued by the user who is performing this adjustment zone by zone, or group of zones by group of zones, by observing the picture. This device is characterised in that it comprises a means for imposing a sequence of adjustment stages following one another in a given order, the correction signals for all of the zones being modified simultaneously in the memory during the first stage by means of a correction table in the microprocessor memory, the number of zones of the image affected by the correction during the subsequent stages then decreasing progressively, the total number of stages being, however, less than the number of

zones of the picture.

The adjustment performed by the user when he is observing the picture consists for example of observing the superimposition of two cursors (simple figures) of different colours.

During the first stage the adjustment is performed by observation of the cursors at the centre of the picture and the computer means, such as a microprocessor, orders modification of the correction values in the memory so as to displace the whole of the red image and of the blue image; that is to say that all of the zones are affected by this first stage of the adjustment. During the subsequent stages, the number of zones affected by the adjustments is progressively reduced.

This automatic adjustment sequence has the advantage that it can be performed more quickly than zone-by-zone adjustment. Moreover it can be further shortened in view of the fact that the first adjustment stages affect the entire picture; that is to say that even as early as the first stage a first overall adjustment of the picture has already been performed, which would not be the case if zone-by-zone adjustment were performed.

To perform the adjustment, the user possesses, in one embodiment, a remote control unit, for example of the usual infra-red type, having buttons each of which enables him to transmit correction commands to be memorised and which are expressed, on the screen, by the displacement of a cursor of given colour in a given direction (horizontal orvvertical). Thus each zone of the random access memory comprises four correction signals: the first for red horizontal, the second for red vertical, the third for blue horizontal and the fourth for blue vertical. When the adjustment has been performed zone by zone, the blue cursor must be displaced for each zone so as to superimpose it on the green cursor and the same operation must be performed for the colour red, i.e. the red cursor must be displaced so as to superimpose it on the green cursor.

Moreover it is preferable for the adjustment to be performed by stepwise displacement of the cursor, each step corresponding to an upward (or downward) increment of each correction value in the zones

of the memory. In this case, to overcome the accumulation, at each step, of the inaccuracies due to the digital nature of the signals, the memorised correction values are advantageously modified, at each step, in the following manner : n increments are subtracted from the contents of the memory, n being the algebraic number of steps taken prior to the last displacement of the cursor and (n + 1) or (n - 1) (depending on the direction of the displacement) times the increment is added to the result of this subtraction.

In a preferred embodiment the videoprojector is of the type usable for standards having different numbers of lines and the microprocessor is capable of calculating the modifications to be made to the correction signal values when the standard is changed without there being any need to repeat the adjustments. Thus a videoprojector which has been adjusted by the user with the SECAM standard can be used automatically, without further adjustment, with an NTSC standard video recorder having 525 lines per frame instead of 625 lines.

In order to divide the picture up into zones, an address generator, for example, is used having an oscillator the frequency of which is an even multiple, e.g. 64, of the horizontal scanning frequency, the signal from this oscillator being synchronised with the line scan signal, and at least one divider having parallel outputs on which signals at decreasing frequencies appear; the states of certain of the pulses are used to represent the horizontal co-ordinates of the zones and other pulses, at lower frequencies, are used to represent, depending on their states, the vertical co-ordinates of the zones. Preferably, the first two outputs from the divider, at the highest frequencies, control the reading (or adjustment) sequence of the four correction signals in each zone of the memory.

For a multi-standard videoprojector the divider has two parts, the first to produce the pulses for reading of the correction signals in each zone and the address pulses in the horizontal direction, and the second to produce the address pulses in the vertical direction, this second part, which is fed by the first, being programmable to modify the number of lines in each zone depending on the standard, one zone comprising for example 24 lines in SECAM and 20 lines in NTSC.

A videoprojector usually also comprises geometry correction circuits acting on the scanning of all three tubes (whereas for the convergence adjustments the scanning of two tubes is manipulated) in order to correct the usual distortions of the television picture such as the north-south cushion, the east-west cushion and the distortions specific to videoprojectors, which are due to the variable inclination of the axes of the tubes with respect to a line perpendicular to the screen. In fact the most usual case is a vertical screen and tubes the axes of which are not in a horizontal plane but in a plane inclined upwards in the direction of the projection; the shape of the projection surface therefore constitutes a possible cause of geometrical distortion of the image.

These geometrical faults are, like the convergence faults, corrected by acting upon the horizontal and vertical deviation fields by means of geometry correction circuits. Certain geometrical corrections are independent of the orientation of the tubes with respect to the screen or of the shape of these tubes; they are generally performed by the manufacturer. The other corrections are performed by the user (or the installer): these are horizontal trapezium, vertical linearity and vertical amplitude faults. The vertical amplitude fault is a deviation from normal of the picture height; the vertical linearity fault consists of failure to maintain distances in the vertical direction and the horizontal trapezium fault is a distortion of the picture which, instead of being rectangular, has the shape of a trapezium with parallel horizontal edges. The adjustment device according to the invention preferably comprises, in addition to the convergence adjustment circuit, such a circuit for geometrical adjustment to be performed by the user, the means for adjustment preferably being, like the convergence adjustments, on a remote control unit.

Other characteristics and advantages of the invention will become apparent with the description of certain of its embodiments, this being given with reference to the attached drawings in which:

- figure 1 is a simplified diagram of a videoprojector having three tubes,

- figure 2 is a general diagram of a circuit according to the invention,

- figure 3 is a diagram of the geometry adjustment part,

- figure 4 shows the division of the picture into zones,

- figure 5 is a diagram of an address generator of the circuit of the invention,

- figures 6_a to 6_h show a part of the signals emitted by the address generator,

- figure 7 is a diagram of a grating and cursor generator forming part of the circuit of the invention,

- figure 8 shows a grating and a cursor,

- figures 9_a and 9_b are diagrams showing an operating characteristic of the circuit of figure 2,

- figure 10 is a diagram of an interpolator forming part of the circuit of the invention

- the diagrams of figures 11_a to 11_f show the operation of the interpolator of figure 10,

- figure 12 shows another part of the circuit of figure 2,

- figure 13 shows yet another part of the circuit of figure 2,

- figure 14 is a diagram of a remote control unit forming part of the device of the invention, and

- figure 15 shows an adjustment sequence.

In the example the videoprojector 10 comprises three monochrome tubes 11, 12 and 13 projecting images respectively of colours green G, red R and blue B onto a screen 14 by means of lenses, 11_1, 12_1 and 13_1 respectively.

Each tube comprises main deviators to provide the horizontal and vertical scans of the electron beam produced by the electron gun in that tube and a pair of auxiliary deviators also acting on the electron beam to perform the geometrical and convergence corrections. In figure 1, for the green tube 11, the main pair of deviators bears the reference 11_2 and the auxiliary pair bears the reference 11_3.

Each pair of deviators consists of two windings, one 14 for the horizontal deviation and the other 15 for the vertical deviation. In figure 2 an index has been added to the reference figures for each of these windings corresponding to the colour of the corresponding tube, G for green, R for red and B for blue. Each winding is supplied with electrical current by a convergence amplifier, of reference 16 for the horizontal deviation and of reference 17 for the vertical deviation. Each amplifier 16, 17 supplies on its output a current of intensity proportional to the voltage present on its input. The deviation of the spot on the screen with respect to its nominal position is proportional to the intensity of the current passing through the deviator.

Figure 2 shows, on the one hand, the geometry correction circuit 18 and, on the other hand, the convergence adjustment circuit 19. The geometry correction circuit 18 has two outputs 18_1 and 18_2 supplying the inputs of all of the horizontal and vertical convergence amplifiers, and a third output 18_3 controlling an east-west modulator (not shown) associated with the main deviators. As will be seen below in connection with figure 3 this circuit 18 has two inputs 18_4 and 18_5 receiving signals at the horizontal (or line) and vertical (or frame) scanning frequencies f_h and f_v respectively.

The geometry correction circuit 18 supplies the three pairs of convergence amplifiers 16 and 17. However the convergence correction circuit 19 supplies only two pairs of convergence amplifiers, those which are associated with the red tube 12 (R) and with the blue tube 13 (B). In order to enable these convergence amplifiers 16_R, 16_B, 17_R, 17_B to be supplied simultaneously by the circuits 18 and 19, an adder 20_R, 21_R, 20_B, 21_B is provided for each of these four amplifiers.

The circuit 19 has, like the circuit 18, two inputs 19_1 and 19_2 receiving signals at the line and frame scanning frequencies f_h and f_v respectively. In front of its four outputs 19_3 to 19_6, supplying the corresponding inputs of the adders 20_R, 21_R, 20_B, 21_B, it comprises digital-analog converters 22_R, 23_R, 22_B, 23_B.

The convergence adjustment circuit 19, the function of which is to superimpose the red and blue images on the green image, is based on the division of the screen into 208 zones: 16 zones numbered from 0 to 15 in figure 4, in the horizontal direction and 13 zones in the vertical direction including one initialisation zone 24 (figure 4) corresponding to the vertical blanking interval. In figure 4 the rectangle 25, delimited by a thick broken line, corresponds to the visible part of the picture on the screen. In the x-axis the time t has been entered in microseconds in addition to the zone numbers in the horizontal direction, and, in the y-axis, the number of scanning lines have been shown from top to bottom for the first half-frame in the SECAM or PAL standard at 625 lines per picture.

Four correction values, i.e. four signals on the outputs 19_3 to 19_6 are allocated to each of the zones.

The division into zones is performed by means of an address generator 26 receiving signals of frequencies f_h and f_v and, to allow the sequence of address signals to be modified in case of a change of standard, by means of a microprocessor 27, also forming part of the circuit 19, and having an input 27_1 receiving signals from a remote control unit (figure 14). The microprocessor also serves to calculate the correction signals.

These correction signals are stored in a random access memory RAM 28 having a 2 kilobyte capacity with an input 28_1 connected to the output from the address generator 26 and an input-output 28_2 connected to an input-output 27_2 of the microprocessor 27. An accumulator (not shown) is associated with this random access memory 28 to safeguard its contents when the circuit is disconnected from its electrical power supply.

The output 28_3 from the memory 28 is connected to the input of an interpolator 29 the function of which is, as will be seen later, to smooth out the correction values from one vertical zone to another (in a single column). The output signals from this interpolator 29 are in series, like the signals from the memory 28; they supply a demultiplexer 30 connected to the four outputs 19_3 to 19_6 through the digital-analog converters 22 and 23.

The microprocessor 27 is used during the convergence adjustment phase to modify the contents of the memory 28 in terms of the commands issued by the user. The microprocessor 27 is also used to convert automatically the correction values stored in the memory 28 when the standard is changed, without requiring action by the user, for example when there is a change-over from the SECAM standard to the NTSC standard at 525 lines per picture. In other words, it is not necessary to perform a fresh adjustment when the standard is changed.

Geometrical correction circuit 18 (figure 3):

This circuit 18 generates signals - which cannot be modified by the user - in order to perform the conventional corrections of geometrical faults intrinsic in television scanning. This circuit 18 also generates signals adjustable by the user by means of the remote control unit acting on the input 18_6. These adjustments accessible to the user are those which make it possible to compensate for the non-perpendicularity with the screen 9 of the three light beams projected by the lenses 11_1, 12_1 and 13_1. These adjustments firstly affect the vertical amplitude, i.e. they modify the height of the picture. They also affect the vertical linearity, i.e. they enable the distances in the vertical direction to be restored. Lastly the user can also perform the "horizontal trapezium" adjustment in order to modify the lengths of the lines to as to restore the rectangular shape of the picture.

The adjustments not accessible to the user also include vertical amplitude, vertical linearity and horizontal trapezium adjustments. In addition, horizontal linearity, horizontal amplitude, horizontal curvature, north-south cushion and east-west cushion corrections are provided.

In order to determine the geometry corrections not adjustable by the user, which are termed "fixed", starting from a reference voltage V_{ref} which is integrated with the line frequency f_h and with the frame frequency f_v signals are formed which are proportional to x, to x^2, to y to y^2, to xy and to x^2y, x and y being respectively the horizontal and vertical co-ordinates of the spot on the screen.

For the corrections accessible to the user, termed "variable", starting from a control voltage V_{cont}, the value of which can be adjusted by the user by means of the remote control unit, this voltage is integrated with the frame frequency to form signals proportional to y and y^2.

The signal V_{ref} is applied to the input of a first integrator 31 re-set at the line frequency f_h and to the input of an integrator 32 re-set at the frame frequency f_v. At the output from the integrator 31 a signal x is obtained which is applied to the input of a second integrator 33 also controlled at the frequency f_h and thus delivering at its output a signal x^2.

The output from the integrator 31 is connected to the first input of a multiplier 34 the second input of which receives the output signal from the integrator 32, i.e. the signal y. Thus the output from the multiplier 34 delivers a signal xy which is applied to one input 35_1 of an adder 35 via a horizontal trapezium adjustment potentiometer 36.

The output signal from the integrator 31 is also applied to a second input 35_2 of the adder 35 via another potentiometer 37 for adjustment of the horizontal amplitude. The adder 35 has a third input 35_3 receiving the output signal x^2 from the integrator 33 with a coefficient which depends on the adjustment of a horizontal linearity potentiometer 39. The output from the adder 35 constitutes the horizontal correction output 18_1 from the generator 18.

The output signal x^2 from the integrator 33 is also applied to the first input 41_1 of another adder 41 via a potentiometer 42 for adjustment of the horizontal curvature. The output from the adder 41 constitutes the vertical correction output 18_2 of the generator 18.

The output xy from the multiplier 34 is applied to the input of another integrator 43 controlled at the line frequency f_h and therefore delivering at its output a signal x^2y which is applied, via a potentiometer 44, to the second input 41_2 of the adder 41. The signal on the input 41_2 performs the north-south cushion correction.

The output from the integrator 32 which delivers a signal y is sent to the third input 41_3 of the adder 41 via a potentiometer 45 for adjustment of the vertical amplitude. The output signal from the integrator 32 is also applied, via a potentiometer 46, to the first input 47_1 of an adder 47 the output from which constitutes the output 18_3 of the circuit 18 which is connected to an east-west modulator, i.e. to a circuit performing a multiplication by x. The signal applied to the input 47_1 performs a horizontal trapezium correction.

The output signal y from the integrator 32 is applied to the input of another integrator 48 controlled at the frame scan frequency and therefore delivering at its output a signal y^2 which is applied, via a potentiometer 49, to the fourth input 41_4 of the adder 41. This signal on the input 41_4 contributes to the vertical linearity correction. The y^2 signal is also applied to the second input 47_2 of the adder 47 via another potentiometer 50 to perform the east-west cushion correction.

The control voltage V_{cont} adjustable by the user by means of the remote control unit (button 130, figure 14) is applied to the input of an integrator 51 controlled at the vertical frequency f_v and thus delivering at its output a signal proportional to y namely αy. This signal αy is sent to the fifth input 41_5 of the adder 41 via a resistor 52 (or several resistors) multiplying by a coefficient K_1. The signal $K_1 \alpha y$ on the input 41_5 enables the vertical amplitude correction to be made.

The output signal αy from the integrator 51 is applied, via one (or several) resistor(s) 53 multiplying by a coefficient K_3, to the third input 47_3 of the adder 47. The signal at 47_3 contributes to the horizontal trapezium correction.

Lastly the signal αy supplies the input of an integrator 54 controlled at the vertical scanning frequency and thus delivering at its output a signal αy^2 which is sent to a sixth input 41_6 of the adder 41 via one (or several) resistor(s) 55 multiplying by a coefficient K_2. The signal $K_2 \alpha y^2$ applied to the input 41_6 enables the vertical linearity correction to be made.

It should be noted that the east-west modulator, which receives the output signals from the adder 47 and forms part of the basic circuit of the videoprojector, makes the correction of greatest amplitude, which is particularly useful for the horizontal trapezium correction which is the largest correction to be made.

Lastly, the reference voltage of the vertical frequency integrators 32, 48, 51 and 54 is adjustable, under the control of the microprocessor 27, when the standard is changed. Also note that, as will be seen later, the reference voltage of the converters 22, 23 is also adjustable and for the same reason.

Convergence adjustment circuit 19

I. Address generator 26 (figure 5).

The signals of frequencies f_h and f_v appearing at the inputs 19_1 and 19_2 are applied to a shaping circuit 60 converting the substantially sinusoidal pulses into rectangular pulses.

This shaping is illustrated in the diagram of figures 6_a and 6_b for the signal at the horizontal scanning frequency: the signal 61 appearing at each line between the 0 and 12µs moments, i.e. during the line-scan flyback period, is applied at the input 19_1. This pulse 61 varies in a substantially sinusoidal manner with a maximum at time t = 6µs. A signal anotated f'_h, also at the horizontal scanning frequency but formed of rectangular pulses 62 (figure 6_b) is obtained at the output 60_1.

The signal f'_h is sent to a phase loop 63 comprising an oscillator 64 controlled by the voltage (VCO) generating at its output 64_1 a signal at the 1 MHz frequency which is sent to a synchronous type divider 65 of quotient sixty four (64). The synchronism of the signal from the oscillator 64 with the input signal f'_h is obtained by means of the connection of an output 65_5 of the divider 65 to the second input of a multiplier 66 the first input of which receives the signal f'_h and the output from which is connected to the control input 64_2 of the oscillator 64.

The synchronous divider 65 has six outputs 65_0 to 65_5 at which appear signals, A_0 to A_5 respectively, which are shown by the diagrams of figures 6_c to 6_h. The signal A_0 is a periodic rectangular

signal of cyclic ratio $\frac{1}{2}$ of frequency 0.5 MHz (half of the frequency of the output signal from the oscillator 64), the signal A_1 has a frequency half that of the signal A_0, the frequency of the signal A_2 is half that of the signal A_1, etc... Thus the signal A_5 has a frequency of 15,625 Hertz, i.e. the line-scan frequency f_h.

The signals A_0 and A_1 are used, in each zone, to control the sequence for memorising (or for reading) of the correction signals for the convergence amplifiers. Thus when $A_0 = 0$ the correction signals for the horizontal auxiliary convergence deviators are memorised (or read); when $A_0 = 1$ it is the correction signals for the vertical deviators which are memorised or read. If $A_1 = 0$ the red channel R is memorised (or acted upon) and if $A_1 = 1$ the actions relate to the blue channel B.

The four remaining signals, A_2 to A_5, constitute the bits of a binary number which represents the number of one of the 16 columns or horizontal zones (figure 4).

The numbers of the rows or vertical zones are produced by means of a programmable divider 68 having outputs 68_6 to 68_9 at which appear four bits A_6 to A_9. The divider 68 is re-set at the start of each frame by means of a control circuit 69 emitting a re-setting pulse applied to an input 68_1. This circuit 69 is connected, for this purpose, to the output 60_2 of the shaping circuit 60 and therefore receives on one input 69_1 a rectangular signal f'_v at vertical scanning frequency.

The circuit 69 comprises another input 69_2 receiving a signal representative of the standard, that is to say of the number of lines per frame. In fact, the image being divided into a constant number (13) of rows, the number of lines per zone will vary with the standard. Thus in the 625 line standard, each zone comprises 24 lines per half-frame whereas in the 525 line standard each of these zones comprises 20 lines per half-frame. In these conditions the control circuit 69 has four parallel outputs 69_3 to 69_6 connected to corresponding inputs of the divider 68 so that the division factor is such that each zone thus comprises the corresponding number of lines per half-frame.

Lastly the circuit 69 has an output 69_7 adapted to control, as will be seen below, the transfer of an initial value from the memory 28 to an integrator forming part of the interpolator 29.

The purpose of this interpolator is to smooth out the correction values from one vertical zone to another.

II. The smoothing between the contiguous zones in the horizontal direction is performed naturally by the response times of the auxiliary windings and of the convergence amplifiers. The response of a convergence amplifier with the associated winding is shown in figures 9_a and 9_b. Figure 9_a represents a signal v applied to the input of a convergence amplifier and figure 9_b shows the signal Δx obtained in the corresponding winding. The amplifier-winding assembly thus has a Bessel response having a rise time equal to the width (4μs) of one zone in the horizontal direction.

III. Interpolator 29 (figures 10 and 11)

The difficulty (compared with the horizontal smoothing) of smoothing in the vertical direction is due to the fact that the zones in question are not contiguous in time.

Before describing the interpolator 29, with reference to figure 10, we shall first explain, with the diagrams of figures 11_a to 11_f, the principle of this linear interpolation.

The linear interpolation is performed by allocating to each initial zone during the frame flyback a constant value represented by the segment 70 in figure 11_a and the segment 71 in figure 11_b. However, in the other zones of the same vertical column the correction signals do not remain constant but vary in a linear manner. This linear variation is represented by the segments 71_1, 71_2, etc... in figure 11_b. The rate of linear variation generally differs from one zone to another. In other words, to each zone, a constant value is allocated which is the slope of the segments 71_1, 71_2, i.e. the rate of variation of the correction signal in that zone. Thus in figure 11_a, the slope of the first visible zone of the picture is represented by the segment 70_1, the slope for the second zone is represented by the segment 70_2, etc...

Of course, the contiguous segments of figure 11_b connect up with one another; that is to say that at each change of zone in the vertical direction there is no discontinuity but simply a change of slope. In a zone of number i the correction signal v_{si} (figure 11_b) varies as follows :

$$(1) \quad V_{Si} = V_{Si-1} + \frac{1}{T} V_{ei} \quad (t-t_{i-1}).$$

In this formula: T represents the duration of one zone in the vertical direction, i.e., in the example, at the duration of 24 lines (in the 625 line standard) or 20 lines (525 line standard), V_{Si-1} is the value reached by the signal V_s at the last line of the preceding zone, and t_{i-1} is the moment at which the zone starts.

Note that the segments 70, 70_1 and also the segments 71, 71_1, 71_2... of figure 11_b represent packets of signals and not signals since the latter appear only during 1/16th of the duration of each line (width of a column). In other words, the segments 70 and 71 are not, as shown, continuous segments but successions of segments parallel with the x-axis.

When modification of the correction signal in a visible picture column is required, the slope in that zone is increased (or reduced), i.e. the signal V_e for that zone is increased (or reduced) by a quantity ΔV_e. But in order not to affect the following zones the signal of the immediately following vertical zone is reduced (or increased) by the same quantity ΔV_e (figure 11_c). Thus, as figure 11_d shows, the signal V_s is modified only for the zone in question and the following zone. As a variant, for the said modification, it is possible to act upon the preceding zone instead of the following zone.

For a correction of a single value for all the zones of a single column (figure 11_f) it is sufficient to offset the signal V_e assigned to the initial zone (frame flyback) by the corresponding quantity so as to obtain the required result (figure 11_e).

It should be noted here that four correction values correspond to each zone: red horizontal, red vertical, blue horizontal and blue vertical. In other words, four segments 70 are provided in the initial

zone and four slope values are provided for the visible zones.

The interpolator performing the functions described in connection with figure 11 is shown in figure 10. It comprises a multiplexed digital integrator constituted mainly by a buffer memory 75 having a capacity of 64 twelve bit words and by an adder 76 adding twelve bit words.

The integration consists, for each line, of increasing the content of the memory 75 by the value of one increment depending on the value of the signal V_e in the zone in question (figure 11_a). This increase is performed by means of the adder 76. Referring to the formula (1) we see that the increment has the value of $\frac{V_{ei}}{24}$ in 625 line standard and $\frac{V_{ei}}{20}$ in NTSC standard.

The integrator receives its information from the memory 28 and from the control signals of the address generator 26.

In figure 10 the line 77 is connected to the output from the memory 28. It applies these eight bit digital signals, on the one hand, to one input 76_1 of the adder 76 and, on the other hand, to the input 78_1 of a holding circuit 78. The signals supplied by the address generator 26 are, firstly, a 1 MHz signal on a line 79 routed to the input 80_1 of a control circuit 80, secondly, a control signal V_1 of initial value at the end of the frame flyback (on line 22 in the PAL-SECAM system) routed by a line 81 connected to the input 80_2 of the control circuit 80 and, thirdly and lastly, address signals A_0 to A_5, corresponding to the number of the column in question, routed by a line 82 to an input 75_1 of the memory 75. The control circuit 80 supplies a read-write signal R/W on a corresponding input 75_2 of the memory 75 and also read-write signals on inputs 78_2 and 83_1 respectively of the holding circuits 78 and 83.

The buffer memory 75 has an input-output 75_3 for the data which is connected to the output 78_3 of the holding circuit 78, to the second input 76_2 of the adder 76 and to the output 83_2 of the second holding circuit 83 the data input 83_3 of which is connected to the output 76_3 from the adder 76.

This interpolator which has just been described in connection with figure 10 operates in a multiplexed manner and in the manner

in connection with figure 11, namely:

At the end of the frame flyback (on line 22 when the PAL or SECAM system is used) the address generator delivers to the input 80_2 of the circuit 80 an initialisation signal which is sent to the input 78_2 of the holding circuit 78 to authorise the transmission to the buffer memory 75 of the 64 eight bit words supplied by the memory 28 (figure 2) and corresponding to the signal V_e (figure 11_a) for the initial zone and this for all of the 16 columns, each of which includes four correction values: red horizontal, red vertical, blue horizontal and blue vertical.

Since the buffer memory 75 records the words on twelve bits, the eight bits of the words supplied by the memory 28 are heavy weight bits whereas the 4 bits of light weight of each word from the memory 75 are cancelled at this stage.

It is not essential for this phase of loading of the memory 75 to last for only one line. It may last for several lines.

At the following line, after this phase of loading of the memory 75, the integration proper begins: the first correction value V_e (expressed by a visible signal), which corresponds for example to the red horizontal, for the zone 0 is delivered to the input 76_2 of the adder 76 and is added to an increment of eight bits supplied on the input 76_1 by the memory 28. This increment has the value $\frac{V_0}{24}$ when each vertical zone comprises 24 lines (see formula (1) above). There is thus obtained at the output 76_3 from the adder 76 a signal V_s which corresponds to the first point 71^1_1 (figure 11_b) of the segment 71_1. The result of the addition, i.e. the above-mentioned signal V_s, which is a twelve bit word, is sent to the memory 75 via the holding circuit 83 and this result replaces the initial value V_0 which was written in this memory 75. This signal V_s at output 83_2 from the holding circuit 83 is also sent, by a line 84, to the demultiplexer 30 (figure 2).

The whole of these operations lasts 1µs. Under the control of the variations of the signals transmitted through the lines 79 and 82 a new value is read from the memory 75, for example that which corresponds to the red vertical of the initial zone (frame flyback).

The process which has just been described is thus re-started: working out of the first integration step. Since the duration of one line is 64µs the 64 correction signals per line are in fact processed.

At the following line the integration process continues, i.e. displacement continues on the segment 71_1. On completion of 24 frame lines, at the end of the first row, the memory 28, under the control of the address generator, delivers a new value V_e for each of the 64 correction signals. The segment 71_2 is run through in this way. The process continues like this until the end of the frame.

IV. Cursor and grating generator (figures 7 and 8)

To facilitate the convergense adjustment there is projected onto the screen a cruciform cursor 85 (figure 8) formed of two bright lines, one vertical 85_1 and the other horizontal 85_2 of the colour (red or blue) to be adjusted and an identical cursor 86 of the colour green, each of these cursors being in the zone to be adjusted.

For the user the adjustment consists of acting upon the remote control unit to displace the cursor 85 so as to superimpose it on the cursor 86.

Also to facilitate the adjustment the zones of the picture are projected onto the screen by means of a grating 87 formed by horizontal and vertical lines of the colour (red or blue) to be adjusted and by another grating 88 identical to the grating 87, but of green colour. The brightness of the lines of the gratings 87 and 88 is less than that of the lines of the cursors 85 and 86.

To generate the cursors and the gratings use is made of the circuit of figure 7 which comprises a shift register 90 with one input 90_1 receiving from the microprocessor 27 the address of the zone in which the adjustment has to be performed. This address consists of one four bit word for the horizontal co-ordinate and of one four bit word for the vertical co-ordinate. The microprocessor 27 also supplies the clock signal H applied to the corresponding input 90_2 of the register 90. The parallel outputs from the latter are applied to the first inputs of a comparator 91 the second inputs 91_2 of which receive the word A_2, A_3.... A_9 representing the scanning of the zones of the screen as was explained above.

At output 91_3 from the comparator 91 a signal is thus obtained only during the time of appearance of the zone in question. This signal is applied to the input 92_1 of a generator 92 of cursor 85 or 86. This generator 92 produces the horizontal and vertical segments 85_2 and 85_1 respectively. It has a validation input 92_2 receiving a validation signal from the microprocessor 27 and two inputs 92_3 and 92_4 receiving the signals A_1 and A_6 respectively supplied by the address generator. It is the transitions of these signals A_1 and A_6 which are used to generate the cursor at the same time as the signal supplied by the comparator 91.

The signals A_1 and A_6 are also used to generate the gratings 87 and 88 by means of a grating generator 93 which comprises, in addition to two inputs 93_1 and 93_2 receiving these signals A_1 and A_6, an input 93_3 for a validation signal from the microprocessor.

The output from the cursor generator 92 is connected to the first input 94_1 of an adder 94 whereas the output from the grating generator 93 is connected to the second input 94_2 of the adder 94. However this adder 94 is such that it applies the coefficient $\frac{1}{2}$ to the signal fed to its input 94_2. Thus the cursor 85 or 86 is brighter than the grating 87 or 88.

The grating 87, 88 enables the zones of the picture to be identified. However in one operating mode termed "automatic", as we shall see later, this grating is not projected onto the screen owing to the application of an inhibition signal to the input 93_3 of the generator 93. In this case the cursor places itself automatically in the zone to be adjusted, its displacement from one zone to another being performed according to a sequence controlled by the microprocessor 27.

V. Demultiplexer 30 and digital-analog converters 22 and 23 (figure 12).

The output line 84 from the interpolator 29 is connected to the inputs of holding circuits 96_R, 96_B, 97_R and 97_B. The holding circuit 96_R posts the correction signals intended for the red colour and for the vertical direction; the circuit 96_B posts the signals

for the blue colour and the vertical direction; the circuits 97_R and 97_B post the correction signals for the horizontal direction and for the red and blue colours respectively. This selective posting is performed by means of control signals supplied by a control circuit (not shown) which, starting from the signals A_0 and A_1 delivers clock signals H_{RV}, H_{BV}, H_{RH} and H_{BH} opening the holding circuits at the moment when the corresponding correction signals appear on the line 84. Moreover these clock signals controlling the holding circuits 96 and 97 are used, at each line and for the corresponding zone, to deliver their content during the 4 s duration of this zone The circuits 96 and 97 thus put the correction signals applied in series to their inputs back into phase.

The digital-analog converters 23_R and 23_B which convert the correction signals for the vertical deviators are of 12 bit capacity to avoid discontinuities in the vertical direction. However the discontinuities in the horizontal direction are less troublesome; that is why the digital analog converters 22_R and 22_B are of the eight bit type.

Moreover between each converter 23 and the corresponding vertical auxiliary convergence deviator is interposed a sampling and holding circuit 99_R, 99_B each of which has a sampling input to which is applied a control signal, S_{RV} and S_{BV} respectively, supplied by the said control circuit working out the signals from the pulses A_0 and A_1. Such sampling and holding circuits enable any possible parasitic intermediate states ("glitches") at the outputs from the converters 23_R and 23_B to be overcome.

VI. Random access memory 28 and microprocessor 27 (figure 13).

The memory 28, of 2 kilobyte capacity, contains correction signals which are applied to the auxiliary convergence deviators during normal use of the videoprojector. This random access memory 28 is loaded during the preliminary adjustment stage, under the control of the microprocessor 27. Thus the address input 28_1 of the memory 28 is connected, on the one hand, to the address generator 26 via a decision switch circuit 100 and, on the other hand, to the address output 27_3 from the central unit 102 of the microprocessor 27 via another decision

switch circuit 101. These circuits 100 and 101 allow the information to pass in only one direction, towards the address input 28_1, and are controlled so that one is blocked while the other is conductive. The circuit 100 transmits the signals A_0 to A_9 on 10 bits to the input 28_1 of the memory 28. The microprocessor output 27_3 supplied 10 bit address signals to the memory 28 during the adjustment phase.

The microprocessor 27 consists of a central unit 102 and of an E PROM memory 103 of 4 kilobyte capacity containing the programmes or programme data for the central unit. The memory 103 has an address input 103_1 connected to the address output 27_3 of the central unit 102. The address signals applied to the input 103 comprise 12 bits. The data output 103_2 of the memory 103 is connected, on the one hand to the data input-output 27_2 of the microprocessor and, on the other hand, by a single bus 105 or data conductor, on which is located a decision switch circuit 106, to the data input-output 28_2 of the memory 28.

The decision switch circuit 106 is, depending on the command it receives, conductive in one direction or the other.

Figure 13 also shows the input 27_1 for the signals received from the remote control unit, the microprocessor input 27_4 to which is applied a signal representative of the standard (generally 525 or 625 lines). Note also an output 27_5 connected to the validation input 93_3 of the grating generator 93 (figure 7), an output 27_6 connected to the input 90_1 of the register 90 which delivers the address of the cursors 85 or 86 and an output 27_7 to control the decision switch circuits 100, 101, 106 and also the memories 28 and 103.

Change of standard.

During normal use (after adjustment), in the mode termed "display" mode, the microprocessor 27 is used to control the modification of the zones and of the correction signals when a signal at the input 27_4 indicates a change in the standard. This signal applied to the input 27_4 of the microprocessor 27 is supplied by a standard detection circuit (not shown) comprising, for example, a simple switch with contacts. The signal from the standard detection

circuit is also sent to the input 69_2 of the circuit 69 for control of the address generator 26 (figure 5) in such a way as to modify the division ratio of the divider 68 and also the counting sequence, particularly the resetting (input 68_1 of the divider 68).

As we have already seen, each zone comprises 20 lines in the 525 line standard and 24 lines in the 625 line standard. Because of the different number of lines in each zone it is clear that the interpolation performed by integration as shown in figure 11 involves different parameters depending on the standard, i.e. the number of lines per frame.

In one embodiment all of the correction signals are modified by means of a calculation, performed by the microprocessor, which consists of replacing all of the values corresponding to the segments 70_1, 70_2, etc... (figure 11_a) by values varying in inverse proportion to the number of lines in each zone.

In another simpler embodiment, the amplitude of the signals delivered by the digital-analog converters 22 and 23 is modified, for example by modifying their reference voltages, in the reverse ratio of the number of lines in each zone; it is possible to act upon the gains of the convergence amplifiers 16 and 17 instead of the reference voltages of the converters 22 and 23. In this embodiment the initial correction values shown by the segments 70 and 71 (figures 11_a and 11_b) are also modified. Thus only one value is modified per column.

By way of example, when the adjustment has been made in the 625 line standard and when one then wishes to use the videoprojector for a 525 line standard the reference voltages of the converters 22, 23 or the gains of the amplifiers 16, 17 are modified in the ratio $\frac{24}{20} = \frac{6}{5}$ and the initial values V_0 are multiplied by the reverse ratio, i.e. 5/6.

In view of the fact that the calculation necessarily involves an approximation and that, in returning to another standard, for example in returning from the 525 line to the 625 line standard, the initial value is thus not necessarily regained, it is necessary to memorise the values of the correction signals obtained during the first adjustment operation. To this end one zone of the random access memory 28 is

used to conserve these values calculated during the adjustment, these values not being subsequently modified, but used as references at each change of standard.

Thus the videoprojector can easily be used with various standards.

If the adjustment has been made in accordance with the 525 line standard, to return to the 625 line standard the initial values V_0 are multiplied by 6/5 and the reference voltage of the digital-analog converters, or the gains of the amplifiers, is modified in a ratio of 5/6.

Remote control unit 110 (figure 14).

To control the videoprojector and perform the adjustments, the user possesses a remote control unit 110 (figure 14) which comprises conventional memorised channel number buttons 111, and buttons 112 for adjustment of audio sound, brightness, colour intensity, station search and tuning frequency. This unit further comprises a set 113 of buttons for the geometrical and convergence corrections, and also a switch 114 which, depending on its position, enables the remote control unit 110 to be used either in normal mode N for control of the videoprojector functions, i.e. for use of the buttons 111 and 112, or in adjustment mode indicated by the "convergence" positions in figure 14 with two positions corresponding to the two, 525 and 625, line standards. In addition a "clear" position is provided for clearing, or returning to an initial state, of the contents of the memory 28.

In the example the adjustment may be performed in two modes: a first mode, termed "manual", in which the convergence adjustment is performed zone by zone, the adjustment made in one zone not affecting the adjustment made in the other zones, and a second mode, termed "automatic", in which each adjustment affects the whole of the picture. The pressing of a button 115 orders adjustment in manual mode. The pressing of a button 116 ensures transfer to automatic mode.

In manual adjustment mode the operation is as follows: The user places the switch 114 into a "convergence" position corresponding to the standard used, for example 625 lines per frame, then

he presses the button 115. Then, at least one grating 87 or 88 and at least one cursor 85 or 86 appear on the screen. He then operates buttons 119_1 to 119_4 in order to bring the cursors 85 and 86 into the zone of the grating for which he wishes to perform the convergence adjustment. The operation of the button 119_1 displaces the cursors vertically downwards; the button 119_2 commands displacement of the cursors also in the vertical direction but upwards; the button 119_3 is assigned to displacement of the cursors horizontally to the left and the button 119_4 performs this horizontal displacement to the right.

Once the cursors are placed in the required zone, the user presses a button 117 for red or 118 for blue. In this position on the screen, the cursor of the colour selected (red or blue) appears as does the grating of the same colour and also the green cursor 86 and the green grating 88 and the effect of the buttons 119 is to displace the red (or blue) cursor 85 with respect to the green cursor 86. Each operation of a button 119 in this position causes, under the control of the microprocessor, a modification of the correction values in the memory 28 for the corresponding zone and for the red (or blue) colour selected. For example each action on the button 119_1, which corresponds to a displacement of one step of the cursor 85 in the vertically downward direction, increases by one increment the corresponding value in the memory 28 whereas each action on the button 119_2 reduces by the same increment the corresponding value in this memory 28. Once the adjustment has been performed for one of the colours the other button 118 or 117 is pressed in order to perform the same adjustment for the other colour.

In this manual adjustment mode, the signals for correction of the convergences in each zone are generated independently of the correction signals for the other zones of the picture. Note however that in order to provide this independence it is necessary to perform in a neighbouring zone in the vertical direction a modification such as that described in connection with figures 11_c and 11_d.

This type of manual adjustment gives good results. But it may be relatively long and tiresome particularly because of the large number of zones of which the picture consists. That is why this adjustment may be used to supplement an adjustment of the automatic type which enables corrections to be performed over the whole of the picture or on a group of zones of the picture at each adjustment sequence.

In automatic mode the microprocessor imposes a sequence of adjustments; that is to say that, as long as he is in this operating mode, the user cannot freely choose the zone in which the pair of cursors is located; during the first stage, this pair is automatically located at a given position, at the centre of the screen in the example. When this first adjustment has been performed for both colours, red and blue, by superimposition of the red cursor, then of the blue cursor, with the green cursor, the pressing of an advance button 120 located under the AUTO button 116 automatically brings the cursor into a second position. The number of adjustment sequences is preferably lower than the number of zones of the picture. In the example the number of cursor positions for which adjustments are made is thirteen (13).

During the first stage, corrections are made over all of the zones; starting from the second stage, corrections are made over all of the zones of half of the picture and then over quarters of the picture.

Figure 15 shows the successive locations at which the pair of cursors appears on the picture 125 when this adjustment is performed in automatic mode:

At point no.1, at the centre of the picture, displacement of the red (or blue) cursor towards the green cursor causes an overall displacement of the red (or blue) image, that is to say that this first adjustment stage affects the position of the whole of the red (or blue) image.

Point no.2 is at the centre of the upper half-picture. Adjustments performed at this point cause a correction of amplitude and of inclination of this upper half-picture, i.e. adjust the magnification and the inclination of the red and blue upper half-images

with respect to the corresponding green half-image.

Point no.3 is at the centre of the lower half-picture. The adjustments are the same for point no.2 but for the lower half-picture.

Point no.4 is at the centre of the right half-picture. The adjustment at this stage affects the amplitude and the inclination of this right half-picture.

Point no.5 is at the centre of the left half-picture. At this point the amplitude and inclination adjustment is performed for the left half-picture.

Points no.6 and no.7 are located at the middles of the upper and lower edges respectively. The adjustments made at these points correct the vertical linearity and the vertical curvature of the red and blue images for the upper and lower half-pictures respectively.

Point no.8 is at the middle of the right vertical edge and point no.9 at the middle of the left vertical edge. At these points the adjustments made correct, for the red and blue images, the horizontal linearity and the horizontal curvature for the right and left half-pictures respectively.

Lastly, points no.10, 11, 12 and 13 are located at the four corners of the picture: top right, top left, bottom left and bottom right. With the cursor in these positions the corrections made are horizontal and vertical trapezium corrections for the corresponding quarter-pictures.

To each adjustment stage in automatic mode corresponds a table of corrections existing in the memory of the microprocessor 27, the table being different from one stage to another. The stepwise displacement of the red or blue cursor by pressing of the buttons 119 causes the transfer, at each pressing of a key 119_i, of one increment value in the corresponding locations of the memory 28 to obtain the desired effect, for example the translation of the whole of the picture during the first adjustment stage. In other words, during the first stage of the adjustment the pressing of the buttons 119 causes modification of the correction signals for all zones of the picture whereas in manual mode this correction affected only a single zone of the picture.

In each table the increments, which are added or subtracted from the corresponding values of the memory 28 are coded on eight bits including one sign bit, three integer part bits and four fractional part bits (after the decimal point).

Since the signals in the various memories are of digital type with a limited number of bits, the result of each addition or subtraction of an increment in each location of the memory 28 is, generally, a value approximated by rounding up or down. The resulting approximation is not troublesome when adding or subtracting a single increment; however unless precautions are taken, the accumulation of these approximations when adding or subtracting several increments in succession may produce errors affecting the quality of the adjustment. To avoid such errors, during stepwise adjustment, additions and subtractions of increments are performed as follows:

The number N of operations of each button 119_i is memorised either in a counter (not shown) or in the memory of the microprocessor, or else in the memory 28. One count is performed for each direction (horizontal or vertical) and for this direction the number N is increased by one unit for an action in one direction and reduced by one unit for an action in the other direction. For example for the vertical direction, the number N increases when the button 119_1 is pressed and is reduced when the button 119_2 is pressed.

The value which is inserted into the memory 28 for the corresponding direction is then calculated as follows when the value N has been increased by one unit: N times the increment is subtracted from the value which existed in the memory 28 and N + 1 (or N - 1 in the opposite direction) times the increment is added to the result. In this manner the inaccuracy or error from rounding up or down is limited to its minimum value since accumulation of the inaccuracies has been avoided.

To give a clear understanding of this aspect of the invention a numerical example of decimal type is given here for clarity of explanation: the simplest case is considered in which one increment corresponds to one translation step. This increment has the

value 2.45; but the memory 28 reads in only integer values. Thus a step in the memory is read in at the value 2 and at the end of four steps, if the steps are accumulated successively the value 8 is obtained in the memory whereas the nominal value corresponds to 4 x 2.45 that is to say 9.90, or practically 10. An error of two units would thus be obtained in the memory, which is unacceptable in practice. However with the adjustment explained above at the end of the first step 2 is actually posted in the memory, but in the second step is posted: 2 - 2.45 = - 0.45 rounded down to 0 and to this value is added 2 x 2.45 = 4.90 rounded up to 5. In the third step: 5 - 2 x 2.45 = 0.1 rounded down to 0 with the addition of 3 x 2.45 = 7.35 that is to say 7; and in the fourth step: 7 - 3 x 2.45 = - 0.35 rounded down to 0 with the addition of 4 x 2.45 = 9.90 rounded up to 10, which is very close to the true value 9.90.

In other words at each step the rounding up or down error of the preceding step is corrected.

These calculations are performed under the control of the microprocessor 27. This process for elimination of the rounding up or down errors is also applicable to the adjustment in manual mode.

To resume the adjustment in automatic mode, it is pointed out here that at each stage of the adjustment the microprocessor 27 performs the following operations. It sends the address of the pair of cursors; it decodes the displacement buttons 119; horizontal direction or vertical, increase or reduction by one unit of the increment; it consults the adjustment table corresponding to the stage, that is to say to the number of the point in figure 15, and, for each zone, it makes the change in the memory 28 depending on the value of the increment. Lastly the pressing of the "advance" button 120 transfers automatically to the next adjustment point. For information, it is mentioned again here that during this adjustment in automatic mode, the gratings 87 and 88 are not projected onto the screen.

It may happen that because of faulty positioning of the tubes with respect to the screen or through unskilful manipulation the number of adjustment steps is so large that the capacity of the memory 75 of the interpolator 29 (figure 10) is exceeded. In this case the content of this memory could revert to the value zero and the adjustments performed earlier would be lost, the cursor returning to an extreme position, and this could be considered by the user to be a fault in the convergence adjustment system. To remedy this disadvantage the microprocessor 27 is programmed to calculate at each incrementation step the value which will be inserted into the memory 75 and to inhibit incrementation when this would lead to exceeding of the capacity of this memory 75. In other words, in this case the cursor stays immobile, which is an indication to the user that he cannot continue the adjustment and that he must either perform it in the opposite direction or check the positioning of the tubes with respect to the screen.

The CLEAR position of the switch 114 (figure 14) enables the contents in each zone of the memory 28 to be returned to zero, or to a given value. This capability is particularly useful for restarting all of the adjustment operations from the beginning when such adjustments have been performed in manual mode on certain zones, which would give the picture an irregular appearance.

If, in automatic mode, a calculation were to be performed for all of the zones requiring modification at each stage and at each step, the adjustment time could be long because of the multiplexed operation of the interpolator 29. This time is further increased by the time of the calculation performed by the microprocessor to check whether or not the capacity of the memory 75 is being exceeded. This is why the microprocessor 27 is programmed so that, in this automatic mode, the adjustment is performed in the following manner:

So long as a button 119 is pressed the adjustment, with modification of the values in the memory 28, is performed only for the zone corresponding to the cursor and the immediately neighbouring zones, simultaneously in the vertical and horizontal directions, so that the

cursor retains its shape on the screen; and the number of adjustment steps made is memorised. When the user stops pressing for a given time, e.g. a half-second, the correction to be made, which depends on the number of steps posted, is extended to all of the zones concerned by this stage of the adjustment, for example all of the zones when the adjustment at point no.1 of figure 15 is made.

Of course if a button 119 is pressed once again the operation is restarted: correction only over the zones corresponding to the cursor, then correction over all of the zones concerned when the key has not been pressed for the said given time.

With this type of adjustment the checking of the exceeding of the capacity of the memory 75 of the interpolator 29 is performed only after the pressing of the button 119_i has been stopped for one half-second and if it is found, by calculation in the microprocessor, that the capacity of the memory 75 could be exceeded, there is introduced into the latter only a number of increments corresponding to the maximum which it can accept.

The adjustment circuit may be delivered to the user with a memory 28 with no contents. It is also possible to insert in-works into the various locations (corresponding to the zones of the picture) of this memory 28, values which correspond to average adjustments, for example for an average given inclination of the plane of the three axes of the tubes with respect to the vertical plane of the screen and for the average angles of inclination of the red and blue tubes with respect to the green central tube. In this case it is advantageous, when the switch 114 is installed in the CLEAR position (figure 14), not to empty the memory 28 but to revert to the preset values.

Note also that the convergence and geometry adjustment circuit of the invention can be used not only for adjustment by the user but also during manufacture for quality inspections.

The d.c. voltages supplying the various electronic components are usually produced from the very high tension supply. This applies to the single reference voltage used for the digital-analog converters 22, 23. It is important for this reference voltage to remain constant or to retain a value enabling the same effect on the electron beam

always to be maintained. It is a fact that when the power supplied by the very high tension increases, the acceleration voltage of the electron beam falls and the effectiveness of the convergence deviators increases, which modifies the adjustment. To remedy this disadvantage a regulator circuit is provided which reduces the reference voltage of the digital-analog converters when the very high tension power rises.

To avoid a manipulation error of the control unit 110 after the adjustments have been made a switch is provided on the frame which, when in a given position, inhibits the action of the buttons 113.

CLAIMS

1. Convergence adjustment device for colour videoprojectors having three monochrome tubes (11, 12, 13) each projecting an image of a determined colour onto a screen (9), this device, of digital type, acting on the scanning of the second (12) and third (13) tubes so as to superimpose, on the screen, their images with that of the first tube (11) and comprising a random access memory (28) in which are stored correction values corresponding to corrections of the scanning currents for the various zones into which the picture is divided, these values being restored to synchronism with the scanning of the zones during normal operation, and a computer means in order, during the adjustment phase, to modify the memorised values depending on the commands issued by the user who performs this adjustment zone by zone, or group of zones by group of zones, by observing the image, characterised in that it comprises a means (27) for imposing a sequence of adjustment stages (figure 15) following one another in a given order, the correction signals of all of the zones being modified simultaneously in the memory during the first stage by means of a table of corrections in the memory of the processor (27), the number of zones of the picture affected by the correction during the subsequent stages then progressively decreasing, the total number of the stages being however less than the number of zones of the picture.

2. Device as claimed in claim 1, characterised in that it comprises: a generator (92) for causing a cursor (86) to be projected by the first tube (11) and, for each of the other two tubes (12, 13), a second cursor (85) of the same shape and a means (114) for commanding the displacement of this second cursor, in order to bring it into coincidence with the cursor of the first tube and to modify, under the control of the computer means (27), the content of the memory in terms of the displacement.

3. Device as claimed in claim 2, characterised in that it comprises a means (93) for projecting simultaneously with the cursors two gratings (87, 88), in principle identical, and formed of horizontal and vertical lines corresponding to the division of the picture into zones, these gratings, which have colours corresponding to the

respective colours of the cursors, having a brightness less than that of the latter.

4. Device as claimed in claim 2 or 3, characterised in that the first stage consists of observing at the centre of the screen the superimposition of the cursors (85) of the second and third colours with the cursor (87) of the first colour, the corresponding memorised correction values being overall translations of the images of the second and third colours.

5. Device as claimed in claim 2 or 4, characterised in that, to limit the adjustment time, when commanding the displacement of the cursor (85), only the zone containing this cursor and, as necessary, the immediately neighbouring zones is (or are) affected by correction signals, the correction signals of the other zones concerned by the adjustment stage not being inserted into the memory (28) until after this displacement.

6. Device as claimed in claim 5, characterised in that the memorising of all of the correction signals supplied by the microprocessor for all of the zones concerned by the adjustment stage, is performed after a given time, for example of the order of one half-second, after the last command for displacement of the cursor.

7. Device as claimed in claim 1, characterised in that the adjustment also being capable of being performed by zones, the adjustment of one zone affecting the correction signals for that zone only, it comprises a means (10) for selection of the adjustment mode: zone by zone, or group of zones by group of zones.

8. Device as claimed in claim 1, characterised in that each correction signal is modified by increments.

9. Device as claimed in any of the above claims, characterised in that in the memory (28) are stored, during manufacture, correction signals corresponding to average correction values, the adjustment consisting of modifying these values inserted into the memory (28), the latter being however retained in another zone of the memory to permit reversion to the pre-recorded correction signals.

* C L M S *

10. Device as claimed in claim 2, characterised in that a means (119) is provided to control the stepwise displacement of the cursor (85), the advance by one step corresponding to the increase by one increment of each correction signal in the zone, or the group of zones, to which the adjustment relates.

11. Device as claimed in claim 10, characterised in that at each displacement step of the cursor each correction signal in the memory is modified in the following manner, in order to limit the inaccuracy on this signal to the minimum: from the correction signal which existed in the memory prior to the displacement by one step, is subtracted n times the increment, n being the algebraic number of steps taken since the start of the adjustment and to the result of this subtraction are added n + 1 or n - 1 increments depending on the direction of displacement of the cursor.

12. Device as claimed in any of the above claims, characterised in that it comprises, to smooth the correction signals between neighbouring zones in the vertical direction, a means (29) for linear interpolation of the correction signals so that, in each zone, the correction signals vary linearly from line to line and so that the signals of two contiguous lines corresponding to different zones have slightly differing values.

13. Device as claimed in claim 12, characterised in that the correction signals for each column are defined by an initial value (V_e) for the zone corresponding to the frame flyback period and, for the other zones by the rate of variation of the correction signals.

14. Device as claimed in claim 13, characterised in that in order to modify the correction signals in one zone the said rate is modified, a modification (ΔV_e) of same value but of opposite sign being performed on the rate of a neighbouring zone of the same column.

15. Device as claimed in claim 13, characterised in that, to modify the correction signals on a column by the same quantity, the initial value is modified in the frame flyback zone.

16. Device as claimed in any of claims 13 to 15, characterised in that the linear interpolator comprises an integrator having a memory (75) and an adder (76), controlled in multiplexed manner so

that this memory and this adder are common to all of the zones and to all of the correction signals.

17. Adjustment device as claimed in any of the above claims, characterised in that the response curves (figure 9_b) of the correction signal amplifiers and of the scanning windings receiving these amplified correction signals are such that they produce smoothing of the correction signals from one zone to another in the horizontal direction.

18. Device as claimed in any of the above claims, characterised in that in order to divide the picture into zones, it comprises an address generator (26) which comprises a generator (64) of pulses of 1 Mhz frequency synchronised with the scanning and at least one frequency divider (65, 68) having parallel outputs, the latter being divided into two groups, a first group representing, depending on its state, the horizontal address of the zone and the second group, at less high frequency, representing depending on its state the vertical address of the zone.

19. Device as claimed in claim 18, characterised in that each zone containing four correction signals: two for the direction: horizontal or vertical, and two for the colour, for example red or blue, the first two outputs (65_0, 65_1) from the divider the frequencies of which are the highest control depending on their states the reading (or the modification) of the type of correction signal to be read or modified.

20. Device as claimed in claim 18 or 19, characterised in that the address generator (26) comprises two dividers, one (65) for generation of the address signals of the zones in the horizontal direction and the other (68) supplied by the first divider, for generation of the address signals in the vertical direction, this second divider being programmable depending on the standard so as to modify the number of lines in each vertical zone in proportion to the number of lines of the standard.

21. Device as claimed in claim 13, characterised in that, in order to control the display, a means is provided sensitive to the standard so that, when there is a change of standard, the initial

* C L M S *

value of each column is modified in the same ratio as the number of lines of the standard is modified and so that the values of the correction signals leaving the memory are modified in the reverse ratio.

22. Device as claimed in claim 21, characterised in that the said modification of the signals in the reverse ratio of the number of standard lines is performed by modification of the gain of amplifiers and/or of the reference voltages of digital-analog converters (22, 23) of the signals leaving the memory.

23. Device as claimed in any of the above claims, characterised in that the correction signals are applied to auxiliary windings (14, 15) for correction of convergence or of geometry of the second and third tubes.

24. Device as claimed in any of the above claims, characterised in that each frame is divided up in the horizontal direction into sixteen zones of equal length and, in the vertical direction into thirteen zones of equal length at least for those visible on the screen.

25. Device as claimed in claim 23, characterised in that the first tube also comprises auxiliary windings (14_V and 15_V) to which the geometry correction signals are applied at the same time as to the auxiliary windings of the other two tubes.

26. Device as claimed in claim 25, characterised in that it comprises a circuit (18) for geometry correction adjustable by the user for performing a vertical amplitude, vertical linearity and horizontal trapezium correction by action on the auxiliary deviators of the three tubes.

27. Device as claimed in claim 26, characterised in that, to perform the said geometry corrections, the user modifies a single signal (V_{cont}).

28. Device as claimed in claim 27, characterised in that it comprises an integrator (51) of a signal at frame frequency the initial value of which is adjustable by the user and the output signal of which is used to perform the said vertical amplitude corrections and the

horizontal trapezium correction and also a second integrator (54) supplied by the output signal from the first integrator (51) to control the linearity correction in the vertical direction.

29. Device as claimed in any of the above claims, characterised in that it comprises a remote control unit (110), for example of the infra-red type, having both buttons for the usual functions of a television receiver and buttons (113) for adjustment.

30. Device as claimed in claims 2 and 29, characterised in that the remote control unit (110) comprises four buttons for controlling the displacement of the cursor, one button (119_1) for downward vertical displacement, one button (119_2) for upward vertical displacement, one button (119_3) for horizontal displacement to the left and one button (119_4) for horizontal displacement to the right.

31. Device as claimed in claims 27 and 28, characterised in that the remote control unit (110) comprises a single button (130) for the geometry correction.

32. Device as claimed in claim 16, characterised in that before the incrementation of the memory (75) of the linear interpolator, the microprocessor (27) determines whether the capacity of the memory is in danger of being exceeded upon completion of this incrementation and inhibits the latter if it would have the effect of exceeding the capacity of the memory.