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(54) TELEVISION DISPLAY APPARATUS EMPLOYING CONVERGENCE CORRECTION

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The invention relates to television display apparatus including a multi-beam colour television display tube, line and field deflection current generators for applying sawtooth-shaped deflection currents of line and field frequency having a substantially constant peak-to-peak amplitude to respective line and field deflection coil systems, a raster correction circuit for correcting for the geometrical properties of the image displayed and a convergence circuit for ensuring correct landing of the electron beams on the screen of the television display tube, at least one of said deflection coil systems being divided into two substantially equal coil portions.

25 The publication "Philips Product Information 13:110° Colour Television Picture Tube and Deflection Principle" of 2nd May 1969 describes a colour television display tube having a deflection angle of 110° and the associated deflection unit. In this case deflection coils are chosen which exhibit anisotropic astigmatism which make it possible with normal deflection fields for the electron beams to be satisfactorily converged without serious colour purity errors along the display axes of the screen, but large convergence errors remain elsewhere and particularly along the display diagonals, which errors cannot be eliminated by conventional convergence circuits. The above publication states that these errors can be corrected if a quadripolar field is generated by the deflection coils, which field is superimposed on the deflection fields. Such a quadripolar field may be obtained by passing an additional current through the deflection coil portions and this in opposite directions, which current—which has been

termed the difference current—must be approximately proportional to the product of the instantaneous values of the two deflection currents. The generator generating the difference current must therefore receive and process information from the two deflection generators. Moreover it may be desirable to adjust the four corners separately. Various steps have been proposed for this purpose which have led to more or less intricate circuits.

For these reasons it has become desirable to use a deflection system which, as in the case of tubes having a deflection angle of 90°, is not or is only slightly, anisotropic astigmatic but is isotropic astigmatic so that the above-mentioned difference current generator can be omitted. When convergence is performed along the display axes of the display screen, the convergence in the corners and along the display diagonals is automatically correct. When using deflection coils of this kind employing 110° tubes it has, however, been found that a remaining convergence error is left, namely an error at which in areas other than those along the axes and in the corners of the screen the green and red landing spots are shifted vertically and the blue landing spots are shifted horizontally. This error cannot be eliminated with known convergence means.

The invention provides television display apparatus including a multi beam colour television display tube, line and field deflection current generators for applying sawtooth-shaped deflection currents of line and field frequency having a substantially constant peak-to-peak amplitude to respective line and field deflection coil systems, a raster correction circuit for correcting for the geometrical properties of the displayed image and a convergence circuit for ensuring correct landing of the electron beams over portions of the screen of said display tube, at least one of said deflection coil systems being formed by two substantially equal coil portions, wherein in order to correct for residual convergence errors

[Price 33p]

Price 75p

which occur at areas other than along the display axes and along the display diagonals of the display tube with deflection coil systems which do not exhibit anisotropic astigmatism, said raster correction circuit also includes a source for generating a substantially sinusoidal convergence correction current of line frequency for application through said deflection coil portions with an amplitude varying at the field frequency which is dependent on the instantaneous intensity of the field deflection current, said source being connected such that said correction current in one coil portion flows in the same direction whilst in the other coil portion flows in a direction opposite to that of the deflection current.

In television display apparatus according to the invention the correction circuit which is present in the display apparatus anyway has an additional function, namely the generation of an additional convergence correction current.

The convergence correction may be still further improved by the raster correction circuit also including a current source which generates a substantially sinusoidal second convergence correction current flowing through the deflection coil portions at double line frequency and with a field frequency varying amplitude which is dependent on the instantaneous value of the field deflection current. This second correction current in one coil portion flowing in the same direction whilst in the other coil portion flowing in the direction opposite to that of the deflection current and being added to the first correction current.

As a result it is possible to use "90°-type" deflection coils. One embodiment of the television display apparatus according to the invention in which the raster correction circuit includes a circuit for the North-South pincushion correction which circuit is arranged in series with the field deflection coil portions which are connected to the field generator at the other end and in which a virtual earth point is present in the said North-South correction circuit has an impedance network arranged between earth and a point on the North-South correction circuit which does not correspond to the virtual earth point.

It may be noted that the above-mentioned error also occurs in 90° tubes, although to a lesser degree, so that the necessity to correct it becomes only really necessary for 110° tubes. It will be evident that the invention may however be used for 90° tubes.

In order that the invention may be readily carried into effect, some embodiments thereof will now be described in detail by way of example with reference to the accompanying diagrammatic drawings in which:

Figure 1 shows a block diagram of part of a known television display apparatus,

Figure 2 shows the error to be corrected,

Figure 3 shows a circuit diagram of an embodiment according to the invention,

Figure 4 shows a waveform which then occurs,

Figure 5 shows the resultant correction,

Figure 6 shows a further embodiment of the invention,

Figures 7 and 8 show waveforms which then occur,

Figure 9 shows a further embodiment of the invention,

Figure 10 shows waveforms which occur in the embodiment according to Figure 9,

Figures 11, 12, 13, 14 and 16 show further embodiments according to the invention, and,

Figure 15 shows the variation of a current in an embodiment according to the invention.

Figure 1 shows a simplified block diagram of part of a colour television display apparatus, for example, a colour television receiver in which the television tube 1 is of the shadow mask type. Three electron guns (not shown) generate three electron beams one of which, beam 2, is shown and impinges upon the display screen 3 of luminescent material at a point 4 after it has been deflected by the magnetic fields which are generated by the deflection coils 5 for the horizontal deflection and 6 for the vertical deflection. Both coils are divided into substantially equal coil halves 5' and 5'' and 6' and 6''. A convergence unit 7 ensures that the three beams coincide in one landing spot.

A line-frequency time base 8 includes a deflection current generator which provides the line deflection current i_H for the coil halves 5' and 5'' which in this embodiment are arranged in parallel. Time base 8 also supplies a signal to the convergence unit 7 in order to provide dynamic line frequency convergence. In a corresponding manner a field frequency time base 9 includes a deflection current generator which provides the field deflection current i_V for the coil halves 6' and 6'' which in this example are arranged in series. Time base 9 also supplies a signal to convergence unit 7 in order to provide dynamic field frequency convergence. Unit 7 also includes known means for the static convergence, i.e. for the convergence in the centre of screen 3.

Furthermore the arrangement includes a raster correction circuit 10 for correcting the geometrical properties of the displayed image. As is known the horizontal deflection is to be influenced in such a manner that the line deflection current i_H is modulated in amplitude by a component at field frequency, while the envelope must be substantially parabolic if the distortion to be corrected is pincushion shaped. This is effected by means of the East West correction circuit 10'. Another raster correction is the North-South correction (in the vertical direction) which is performed

by means of a North-South correction circuit 10". Circuit 10" generates a line frequency correction current i_N at a field frequency amplitude modulation, the line frequency variation being substantially parabolic in case of pincushion distortion while the envelope decreases from a maximum value in a substantially linear manner to zero during a field scan period in the middle of this period, whereafter a substantially equal increase in the reverse direction follows. Circuit 10" therefore receives information from both time base 8 and time base 9 and the current i_N generated thereby is superimposed on the field deflection current i_V . In Figure 1 circuit 10" is arranged in series with deflection coil halves 6' and 6".

Figure 2 is a simplified view of the image displayed on screen 3 of display tube 1 when the image to be displayed consists of horizontal and vertical straight lines, the system of coils 5', 5'', 6', 6'' having substantially no anisotropic astigmatism, this image being obtained after the static and dynamic adjusting members in convergence unit 7 have already been adjusted. It is found that the three electron beams can be registered both along the vertical symmetry axis 11 and along the horizontal symmetry axis 12 and along the sides 13' and 13'' in a satisfactory manner and with few beam landing errors, that is to say, few colour purity errors. Elsewhere on screen 3 an error is still found to occur which is admissible when tube 1 has a deflection angle of 90°, but this error assumes larger proportions in case of a deflection angle of 110° so that a correction is required if the said system of coils is to be used.

The reference numerals 4_R, 4_G and 4_B denote the three landing spots associated with one and the same point to be displayed of the three electron beams in the first quadrant, that is to say, to the right of axis 11 and above axis 12, the error being greatly exaggerated for the sake of clarity. It is found that the red landing spot 4_R is shifted vertically and upwards, the green landing spot 4_G is shifted vertically and downwards and the blue landing spot 4_B is shifted horizontally and to the left. The shifts in the other quadrants are such that the shift for each landing spot changes its sign when passing axis 11 or axis 12. A horizontal line in the upper part of the image is therefore displayed as follows: a substantially undistorted horizontal blue line is produced, a red line undulating about this line which appears to the right of axis 11 above this line and to the left thereof below this line and an undulating green line is produced which has a variation which is opposite to that of this red line, the three lines intersecting on axis 11 and on the sides. The largest deviation occurs approximately in the middle between axis

11 and side 13'' and axis 11 and side 13'' and is 1 to 2 mm in 110° tubes. The vertical line which passes through the same landing spot 4 is displayed as a substantially undistorted yellow vertical line between landing spot 4_G and corresponding points in other quadrants and an oblique substantially straight blue line which intersects the yellow line on axis 12.

The error described hereinbefore is largest along the upper and lower edges of screen 3 and becomes smaller as axis 12 is approached. A correction of this error cannot be satisfactory corrected with the aid of the known convergence unit 7 because the dynamic convergence currents must be modulated, this is to say, the line frequency convergence current would have to undergo a field frequency variation and/or the field frequency convergence current would have to undergo a line frequency variation to a greater extent than before. In addition the shift for the red and green beams is vertical while these beams can only be influenced radially i.e. at an angle of 60° relative to the vertical. All this would be very complicated.

It is realised that to provide the necessary correction it will be necessary to employ the method of difference current drive. This may be evident from Figures 3, 4 and 5. In Figure 3, which is greatly simplified, two substantially equal windings 14' and 14'' whose junction is connected to earth form part of a line deflection current generator associated with line time base 8. Windings 14' and 14'' pass line deflection current i_H through the coil halves 5' and 5'' which in this case are arranged in series for the horizontal deflection. A current source 15 is connected to the junction of coil halves 5' and 5'' to which junction a correction current generated by source 15 is applied. Since the circuit in Figure 3 is symmetrical two substantially identical correction currents flow through coil halves 5' and 5'' which currents are both denoted by i_K . The junction of coil halves 5' and 5'' is a virtual earth point for generator 14', 14'' so that this generator and source 15 do not influence each other. It is found from Figure 3 that currents i_H and i_K in one coil half are added together while they are subtracted from each other in the other coil half.

Correction current i_K has, as a function of time, a variation which is shown in Figure 4 for some lines on either side of the central horizontally displayed line i.e. a substantially sinusoidal function of line frequency, having a field-frequency varying amplitude in which the envelope during a field scan period decreases from a maximum value in a more or less linear manner to zero in the middle of this period whereafter a substantially equal increase in the reverse direction follows. In fact, the current supplied by the field fre-

quency deflection current generator undergoes an S-correction so that the said envelope at the commencement and at the end of the field scan period does not vary in a completely linear manner. In Figure 4 reference H denotes a line period. Current i_K is zero every time at the commencement, in the middle and at the end of each line period.

United States Patent Specification 3,440,483 shows that when correction currents are added and subtracted from the deflection current a magnetic quadripolar field is generated so that the three beams 2_R , 2_G and 2_B are displaced at the area of this field as is shown in Figure 5a. Figure 5b shows on a larger scale the part of screen 3 in the vicinity of landing spots 4_R , 4_G and 4_B . These spots undergo a displacement in the same direction as is shown in Figure 5a and occupy the positions $4'_R$, $4'_G$ and $4'_B$. Figure 5b shows that the remaining deviation between these points has become very small. Since the error to be corrected is zero along sides $13'$ and $13''$ and along axis 11, a line-frequency sinusoidal shape for correction current i_K is suitable. Since the error along axis 12 is zero and is at a maximum at the upper and lower edges a linear envelope of correction current i_K as shown in Figure 4 is therefore suitable. In this case it has been assumed that the line flyback period is short relative to line period H.

It has been realised that it is possible to form current source 15, which generates current i_K , as a part of the North-South correction circuit $10''$. This latter circuit is shown by broken lines in Figure 3. This circuit generates a substantially parabolic current of line frequency which is amplitude-modulated in an analogous manner as current i_K of Figure 4. It is then only necessary to change the parabolic shape of the field correction current into a sinusoidal shape serving for the convergence correction. This can be carried out in a very simple way when, as is often the case in practice, the parabolic shape is approximated by a cosine shape, for example, by making use of a 90° phase-shifting network.

As is known the quadripolar field may alternatively be generated by the deflection coil halves $6'$ and $6''$. Since North-South correction circuit $10''$ is arranged in series with coil halves $6'$ and $6''$ a simpler embodiment is possible starting from the above mentioned aspect. This is shown in Figure 6. In this Figure a voltage source 16 forming part of the field time base 9 supplies a field deflection current i_V to coil halves $6'$ and $6''$ through a transformer 17. A source 18 forming part of correction circuit $10''$ and having an internal impedance of which $18'$ is the reactive part provides the North-South correction current i_N to the same coil halves via a transformer 19 the secondary winding $19''$

of which is arranged in series with these halves so that the same current $i_V + i_N$ passes through them.

One of the ends of the secondary winding $17'$ of transformer 17 is connected to earth. A series network 20, 21 tuned to the line frequency is connected in parallel with winding $17'$. A capacitor 22 whose capacitance has such a value that the elements $6'$, $6''$, $18'$, 19 and 22 form a circuit which is substantially tuned to the line frequency is physically connected in parallel with winding $19''$. Network 20, 21 constitutes a short circuit at the line frequency while the impedance of circuit $19''$, 22 at the field frequency is much lower than the impedance of the coil halves $6'$ and $6''$ at this frequency (at least during the field scan period). Generators 9 and $10''$ cannot therefore substantially influence each other. Due to the symmetry of the circuit a virtual earth point exists in the middle M of winding $19'$. To attenuate possible parasitic oscillations point M may be chosen to be connected to earth through an isolating capacitor and a resistor.

When source 18 generates a sinusoidal voltage of line frequency amplitude modulated by the field frequency, the North-South correction current i_N is cosine-shaped, because the load on circuit $19''$, 22 is substantially purely inductive. As is shown in Figure 7a and i_N is at a maximum in the middle of the line period H and during the line scan period L it is an approximation of the required parabolic current. The series arrangement of an isolating capacitor 23 (for example 100 nf) and a resistor 24 (for example, 1 to 2 k.ohm) may be connected to junction Q of circuit $19''$, 22 and coil half $6''$ instead of to point M, a voltage which has the same shape as that of source 18 then being produced across the resistor 24, i.e. a sinusoidal voltage, while the said parasitic oscillations remain attenuated. An additional current i'_K (see Figure 7b) which is sinusoidal is therefore impressed on both coil halves $6'$ and $6''$, which current flows in one coil half in a direction opposite to that of the currents i_V and i_N and in the other coil half in the same direction as currents i_V and i_N and has approximately the same variation as current i_K of Figure 4. Current i'_K is the desired difference current and generates the required quadripolar field.

The foregoing only applies when the voltage across resistor 24 originates from a source which may be considered as a current source, that is to say, when the resistance of resistor 24 is large relative to the impedance for the line frequency of the inductances through which current i'_K flows. Otherwise current i'_K would have a cosine-shaped component and would therefore not be zero in the middle of the line scan period. In a prac-

tical embodiment of Figure 6 the inductance of the antiparallel-arranged coil halves 6' and 6'' was approximately 3.6 mH which is an impedance of approximately 360 ohms for the line frequency. Antiparallel is understood to mean that the inductance of the system 6', 6'' is measured from point Q with a short-circuit provided across components 19'', 22. The resistance of resistor 24 was therefore approximately 3 to 5.5 times larger. A still better result is achieved by choosing the capacitance for capacitor 23 such that it and the total effective inductance in series with the capacitor. Together constitutes a circuit having a resonant frequency which is the line frequency. In this example this capacitance is approximately 28 nF. The said inductance and capacitor 23 constitutes a series network whose impedance for the line frequency is very low and is therefore much lower than the resistance of resistor 24. This simple step has the advantage that capacitor 23 may have a smaller size and be cheaper. It is thus found that the invention does not require any extra components and makes an existing component even cheaper.

Resistor 24 may advantageously be formed as an adjustable resistor so that the correction can be brought to the desired value. It is alternatively possible to connect resistor 24 in parallel with coil half 6'' or part thereof with the same effect as described above. Alternatively the correction may be adjusted by arranging the network 23, 24 between a tap on winding 19'' and earth but not between point M and earth because there is no line frequency potential difference between them. It may be noted that the polarity of the correction obtained is reversed when a change-over is made from a given tap to another tap which is symmetrical relative to point M.

In practice those networks of Figure 6 stated to be tuned to the line frequency, (excepting network 20, 21), are in fact tuned to a lower frequency, for example, 12.5 kHz so that the parabolic shape of Figure 7a is better approximated. The line frequency is in fact 15,625 Hz for 625 lines per raster, 25 rasters per second. A condition therefore is that the obtained waveform is shifted in phase, for example by means of an inductor, in order that the maximum value of current i_N is reached in the middle of period L. In Figure 8a curve *f* shows the substantially sinusoidal convergence error indicated in Figure 2, which error is zero at the commencement, in the middle and at the end of a line scan period L while curve *k* shows the correction component provided by the present arrangement. The frequency thereof is lower so that curve *k* intersects the zero axis only in the middle of period L. Curve *r* shows the obtained resultant residual error. Figure 8b shows the same curves with a smaller ampli-

tude for curve *k*. These Figures show that the points P and P' in which the remaining deviation is zero can be shifted by means of this amplitude and therefore by means of adjusting the value of resistor 24. A compromise can be found between the position of points P and P' and the largest deviation still remaining. A deviation is also present when all networks of Figure 6 are tuned exactly to the line frequency. In this case curve *k* of Figures 8a and 8b will not intersect the zero axis at the same points as curve *f*.

Figure 9 shows a circuit in which the mentioned deviation can be reduced even more so that there is substantially no convergence error of the kind shown in Figure 2. As a result deflection coils which would otherwise be rejected because the convergence error is too large can still be used.

The North-South correction circuit 10'' is often formed in such a manner that the series arrangement of a capacitor 22 and an LC parallel network 30, 31' is arranged in parallel with winding 19'', the inductor 31' in this parallel network being adjusted in such a manner that the entire circuit of Figure 9 has one parallel resonance of the line frequency and one at double the value thereof. Capacitor 22 of Figure 9 has a slightly lower capacitance than that in Figure 6. In a practical embodiment the capacitance of capacitor 22 is approximately 47 nF, that of capacitor 30 is approximately 390 nF and the inductance of coil 31' is approximately 65 μ H. For the line frequency network 30, 31' represents a very low inductance so that the adjustment of coil 31' does not have substantially any disturbing influence thereon. A voltage which is the sum of two sinusoidal voltages, one of the line frequency and one of the double line frequency, is present across winding 19'' so that the North-South correction current i_N is the sum of two cosine-shaped currents having the mentioned frequencies. The path through which this current flows is substantially purely inductive. As is known a better approximation of the required parabolic shape in Figure 7a is obtained thereby. If necessary, time base 9 may also be decoupled at double line frequency.

When the series arrangement of capacitor 23 and resistor 24 is connected to point Q through a winding 31'' coupled, for example, magnetically to coil 31', a voltage which is the sum of two voltages, to wit a voltage of line frequency and a voltage of double line frequency is produced across this resistor.

Figure 10 shows the shape for a line period H of the generated correction current. In Figure 10a the fundamental waveform k_1 thereof, which corresponds to curve *k* of Figure 8a, is shown. It is found that wave k_1 , unlike the error *f* to be corrected is not

zero at the commencement and at the end of the line scan period L so that a residual error will still remain. Figure 10b shows the wave k_2 of double line frequency and Figure 10c shows the wave k_3 which is the sum of waves k_1 and k_2 . It is found that the ratio between the waves k_1 and k_2 can be chosen to be such that wave k_3 is zero, as desired, at the commencement and at the end of the period L so that the convergence error is further reduced.

When the winding sense of windings 31' and 31'' is such that wave k_2 has the phase shown in Figure 10b, the correction h_3 obtained on either side of the middle of period L will be larger than the correction h_1 which is only obtained by wave k_1 , while correction h_3 just after the commencement and just before the end of the period L is smaller than correction h_1 . Wave k_2 therefore has the desired polarity relative to wave k_1 . It may be noted that the voltage across network 30, 31' also has the desired polarity so that network 23, 24 may be connected to the junction of network 30, 31' and capacitor 22 or to a tap on winding 31'. However, this voltage does not necessarily have the desired amplitude so that a transformer coupling gives an additional degree of freedom.

An advantage of the above is that correction h_3 can be made equal to correction h_1 by giving resistor 24 a higher value so that this resistor behaves even better as a current source, while source 18 is still less loaded. The adjustment of resistor 24 only influences the amplitude of the correction current and not its shape, which shape is determined by the ratio between waves k_1 and k_2 that is to say, by the transformation ratio between windings 31' and 31'' which may be fixed for a given display apparatus.

It may be noted that network 30, 31', 31'' is used for two purposes without a compromise between them being necessary and without separate adjustment being necessary. Likewise as in Figure 6 the series arrangement of resistor 24 and winding 31'' in Figure 9 may be connected in parallel with coil half 6'' or part thereof. Also the correction may be adjusted by arranging the network 31'', 23, 24 between a tap on winding 19'' and earth but not between point M and earth.

Source 18 of Figures 6 and 9, likewise as with source 15 of Figure 3 is any known source in a North-South correction circuit. Active circuits are known for this purpose which consist of, for example, an amplifier having a class B transistor output stage. Passive circuits are also known for this purpose. Figure 11 shows part of such a circuit in which a transducer 26 is used whose two primary windings 26' and 26'' receive line frequency pulses of opposite polarity while a secondary winding 26''' thereof is connected

in series with coil halves 6' and 6''. The North-South correction may be adjusted in balance and in phase and amplitude with the aid of a variable positioned magnet 27, an adjustable inductor 28 and an adjustable resistor 29. Due to the selective character of elements 28, 22, 30 and 31' the two required sinusoidal voltages of substantially line and double line frequency for providing the variation of the field frequency signal are produced across winding 26'''. The correction network 31'', 23, 24 may be arranged between a point of the series arrangement of winding 26''' and coil 28 and earth. It is to be noted that the central point M' of the winding may also be chosen because this point is not a virtual earth point due to the presence of inductor 28, which is in contrast with point M of Figures 6 and 9. In fact, the virtual earth point is a point M of winding 26''', which is located in Figure 11 above point M'.

In the given embodiments the field deflection coil halves are arranged in series so that both the field deflection current generator and the North-South correction circuit have to be incorporated in the formed series circuit while correction network 31'', 23, 24 has to be arranged outside this circuit. In Figure 12, which corresponds to Figure 6, deflection current generator 16 supplies field deflection current i_v to the parallel-arranged coil halves 6' and 6'' through a centre tapped transformer 19 source 18, which may include a transducer, supplies current i_N to coil halves 6' and 6'' through the central tap on the secondary winding 19'' of transformer 19 which then functions as a symmetrical transformer. Winding 19'' is arranged in series with coil halves 6' and 6''. Series network 20, 21 which is tuned to the line frequency is connected in parallel with source 16 while capacitor 22 is connected in parallel with source 18. The series arrangement of capacitor 23 and resistor 24 is then connected to one end of the primary winding 19' of transformer 19 while the other end of winding 19' is connected to the non-earthed terminal of source 18.

In Figure 13, which corresponds to Figure 9, capacitor 22 and the series arrangement of capacitor 30 and coil 31 are connected in parallel with source 18, while capacitor 22 must have a slightly lower capacitance than that in Figure 12. The end of primary winding 19' remote from network 23, 24 is then not connected to source 18, but to a tap on coil 31 which is to be chosen in such a manner that the correction current has the desired amplitude. A magnetic coupling with coil 31 is of course also possible.

Since the transformer 19 is a symmetrical transformer and since resistor 24 may be adjustable, the transformation ratio between windings 19' and 19'' can be freely chosen.

For example, the ratio 1:2 may be chosen. In this case one winding may be economized and the modification according to Figure 14 is obtained in which network 23, 24 is arranged between the junction of coil half 6' and winding 19'' and the tap on coil 31. It may be noted that the junction of source 16 and coil halves 6' and 6'' is connected to earth by network 20, 21 with respect to the line frequency so that the end of resistor 24 connected to earth in Figures 12 and 13 and the end of capacitor 30 connected to earth in Figure 14 may also be connected to the said junction.

It has been stated in the foregoing that the field frequency envelope of the convergence correction current does not vary linearly, because the field deflection current is "S-corrected". In practice it has, however, been found that over correction may be obtained at the commencement and at the end of the field scan period, that is to say, an overcompensation occurs in the upper part and the lower part of the displayed image. This envelope must therefore undergo a larger than normal S-correction than field deflection current i_v . A simple step is possible for this purpose. The desired effect is obtained if one coil half, for example, coil half 6' is bridged by a voltage-dependent resistor VDR. As long as current $i_v + i_N$ is low, the voltage drop across coil half 6' is low so that the current i_{VDR} flowing through the VDR is small. The VDR is then to be considered as a negligible attenuation. When current i_v increases in one or the other direction, this voltage drop is high and current i_{VDR} increases non-linearly because the current-voltage characteristic of the VDR has an exponential variation. Current i_{VDR} therefore has the shape, as a function of time, shown in Figure 15 in which the field scan period is denoted by V. This current is subtracted from the correction current which flows through coil half 6'. In case of suitable choice of the VDR the desired correction is thus obtained. A capacitor 32 may be arranged in series with the VDR, the total inductance of the circuit and this capacitor constituting a circuit which is tuned to the line frequency. As a result the VDR behaves substantially as a current source. This series arrangement may be provided, irrespective of whether coil halves 6' and 6'' are arranged in parallel or in series for current $i_v + i_N$. This is therefore possible for all embodiments described but has only been shown in Figures 6 and 12 for the sake of simplicity.

A drawback of the desired circuits in which the required convergence correction current is generated by the North-South correction circuit is that the zero transition point of Figure 4 coincides with that of the North-South pincushion correction current. This means that these two forms of correction

are zero for a given horizontal line which may be adjusted, for example, by adjustment of magnet 27 in Figure 11. It may be desired that the zero transition point of the correction current in Figure 4 should be capable of separate adjustment from the pincushion correction for example, because the North-South distortion is not symmetrical relative to the central horizontal line on screen 3. This may be achieved in a simple manner by passing an additional line-frequency current of substantially sinusoidal shape whose amplitude is constant but may be adjusted, this current being passed through the deflection coil halves which current in one coil half is added to the deflection current and in the other coil half is subtracted from the deflection current. As a result the correction quadripolar field in one half of the field scan period is enlarged and in the other half it is reduced. By adjusting the amplitude of this current the position of the zero transition point in Figure 4 is adjusted. This current may flow through the line deflection coil halves or through the field deflection coil halves or both. Figure 16 shows a possible embodiment. Capacitor 41 for S-correction is arranged between the central tap on the primary winding of a centre tapped transformer 40 and the line deflection current generator in time base 8. A parabolic voltage is present across this capacitor. An adjustable coil and the secondary winding of transformer 40 are arranged between the centre tap and earth. The current i''_K of constant amplitude flows through deflection coil halves 5' and 5'' in the given direction in which the amplitude is adjustable by means of coil 42. Current i''_K is the integral of the voltage across capacitor 41 and is therefore a third-order function, i.e. substantially a sinusoidal function.

It is to be noted that the correction current in all described examples originates from a current source. A voltage source would also be possible but it will be evident that the corresponding circuit arrangement would be far more complicated.

It may be noted that convergence errors other than those of Figure 2 are feasible for which the described simple step would not be adequate. In that case network 23, 24 might be replaced by another suitable network comprising, for example, an inductor or a voltage-dependent resistor.

WHAT WE CLAIM IS:—

1. Television display apparatus including a multi beam colour television display tube, line and field deflection current generators for applying sawtooth-shaped deflection currents of line and field frequency having a substantially constant peak-to-peak amplitude to respective line and field deflection coil systems, a raster correction circuit for correcting for the geometrical properties of the displayed



For example, the ratio 1:2 may be chosen. In this case one winding may be economized and the modification according to Figure 14 is obtained in which network 23, 24 is arranged between the junction of coil half 6' and winding 19'' and the tap on coil 31. It may be noted that the junction of source 16 and coil halves 6' and 6'' is connected to earth by network 20, 21 with respect to the line frequency so that the end of resistor 24 connected to earth in Figures 12 and 13 and the end of capacitor 30 connected to earth in Figure 14 may also be connected to the said junction.

It has been stated in the foregoing that the field frequency envelope of the convergence correction current does not vary linearly, because the field deflection current is "S-corrected". In practice it has, however, been found that over correction may be obtained at the commencement and at the end of the field scan period, that is to say, an overcompensation occurs in the upper part and the lower part of the displayed image. This envelope must therefore undergo a larger than normal S-correction than field deflection current i_v . A simple step is possible for this purpose. The desired effect is obtained if one coil half, for example, coil half 6' is bridged by a voltage-dependent resistor VDR. As long as current $I_v + i_N$ is low, the voltage drop across coil half 6' is low so that the current i_{VDR} flowing through the VDR is small. The VDR is then to be considered as a negligible attenuation. When current i_v increases in one or the other direction, this voltage drop is high and current i_{VDR} increases non-linearly because the current-voltage characteristic of the VDR has an exponential variation. Current i_{VDR} therefore has the shape, as a function of time, shown in Figure 15 in which the field scan period is denoted by V. This current is subtracted from the correction current which flows through coil half 6'. In case of suitable choice of the VDR the desired correction is thus obtained. A capacitor 32 may be arranged in series with the VDR, the total inductance of the circuit and this capacitor constituting a circuit which is tuned to the line frequency. As a result the VDR behaves substantially as a current source. This series arrangement may be provided, irrespective of whether coil halves 6' and 6'' are arranged in parallel or in series for current $i_v + i_N$. This is therefore possible for all embodiments described but has only been shown in Figures 6 and 12 for the sake of simplicity.

A drawback of the desired circuits in which the required convergence correction current is generated by the North-South correction circuit is that the zero transition point of Figure 4 coincides with that of the North-South pincushion correction current. This means that these two forms of correction

are zero for a given horizontal line which may be adjusted, for example, by adjustment of magnet 27 in Figure 11. It may be desired that the zero transition point of the correction current in Figure 4 should be capable of separate adjustment from the pincushion correction for example, because the North-South distortion is not symmetrical relative to the central horizontal line on screen 3. This may be achieved in a simple manner by passing an additional line-frequency current of substantially sinusoidal shape whose amplitude is constant but may be adjusted, this current being passed through the deflection coil halves which current in one coil half is added to the deflection current and in the other coil half is subtracted from the deflection current. As a result the correction quadripolar field in one half of the field scan period is enlarged and in the other half it is reduced. By adjusting the amplitude of this current the position of the zero transition point in Figure 4 is adjusted. This current may flow through the line deflection coil halves or through the field deflection coil halves or both. Figure 16 shows a possible embodiment. Capacitor 41 for S-correction is arranged between the central tap on the primary winding of a centre tapped transformer 40 and the line deflection current generator in time base 8. A parabolic voltage is present across this capacitor. An adjustable coil and the secondary winding of transformer 40 are arranged between the centre tap and earth. The current i''_K of constant amplitude flows through deflection coil halves 5' and 5'' in the given direction in which the amplitude is adjustable by means of coil 42. Current i''_K is the integral of the voltage across capacitor 41 and is therefore a third-order function, i.e. substantially a sinusoidal function.

It is to be noted that the correction current in all described examples originates from a current source. A voltage source would also be possible but it will be evident that the corresponding circuit arrangement would be far more complicated.

It may be noted that convergence errors other than those of Figure 2 are feasible for which the described simple step would not be adequate. In that case network 23, 24 might be replaced by another suitable network comprising, for example, an inductor or a voltage-dependent resistor.

WHAT WE CLAIM IS:—

1. Television display apparatus including a multi beam colour television display tube, line and field deflection current generators for applying sawtooth-shaped deflection currents of line and field frequency having a substantially constant peak-to-peak amplitude to respective line and field deflection coil systems, a raster correction circuit for correcting for the geometrical properties of the displayed



image and a convergence circuit for ensuring correct landing of the electron beams over portions of the screen of said display tube, at least one of said deflection coil systems being formed by two substantially equal coil portions, wherein in order to correct for residual convergence errors which occur at areas other than along the display axes and along the display diagonals of the displayed tube with deflection coil systems which do not exhibit anisotropic astigmatism, said raster correction circuit also includes a source for generating a substantially sinusoidal convergence correction current of line frequency for application through said deflection coil portions with an amplitude varying at the field frequency which is dependent on the instantaneous intensity of the field deflection current, said source being connected such that said correction current in one coil portion flows in the same direction whilst in the other coil portion flows in a direction opposite to that of the deflection current.

2. Television display apparatus as claimed in Claim 1, in which said raster correction circuit includes a current source for generating a substantially sinusoidal second convergence correction current for application through said deflection coil portions at double line frequency and with a field frequency varying amplitude which is dependent on the instantaneous value of the field deflection current, said source being connected such that said second correction current in one coil portion flows in the same direction whilst in the other coil portion flows in a direction opposite to that of the deflection current and being added to the first correction current.

3. Television display apparatus as claimed in Claim 1, in which said raster correction circuit includes a circuit providing North-South pincushion correction which circuit is arranged in series with the portions of the field deflection coil system which portions are connected to said field deflection generator at this other end, a virtual earth point being present in said North-South correction circuit, an impedance network being arranged between earth and a point on the North-South correction circuit which does not correspond with said virtual earth point.

4. Television display apparatus as claimed in Claims 2 and 3 in which the circuit providing North-South pincushion correction also includes a source for generating a current

of double line frequency, said impedance network is coupled to the said source.

5. Television display apparatus as claimed in Claim 4, in which said source includes an L-C network, said impedance network is coupled to the inductor in said L-C network.

6. Television display apparatus as claimed in Claim 3 or 4, in which the circuit providing North-South pincushion correction includes a transformer or a transductor, a secondary winding of which is arranged in series with the portions of the field deflection coil system and optionally with an inductor, said impedance network being connected to a point of the said series arrangement which does not correspond with said virtual earth point.

7. Television display apparatus as claimed in any of Claims 3 to 6, in which said impedance network comprises a resistor.

8. Television display apparatus as claimed in any of Claims 3 to 6, in which said impedance network comprises the series arrangement of a resistor and a capacitor, said capacitor having a capacitance such that it constitutes, together with the total inductance of the circuit formed by the field deflection coil portion and the networks coupled thereto, a circuit having a resonant frequency which is equal to or less than the line frequency.

9. Television display apparatus as claimed in any of Claims 1 or 2, in that said field system is formed by two substantially equal coil portions one of which deflection coil is shunted by the series arrangement of a voltage-dependent resistor and a capacitor, said capacitor having a capacitance at which it constitutes, together with the total inductance of the circuit constituted by the field deflection coil portions and the networks coupled thereto, a circuit having a resonant frequency which is equal to or less than the line frequency.

10. Television display apparatus as claimed in any of Claims 3 to 9, in which a constant amplitude substantially sinusoidal current of line frequency flows through the deflection coil portions, which current in one coil portion flows in the same direction whilst in the other coil portion flows in the direction opposite to the deflection current.

11. Television display apparatus as claimed in Claim 10, characterized in that the said current flows through the coil portions forming the line deflection coil system, the current



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being supplied by the voltage present across the S-capacitor.

- 5 12. Television display apparatus employing convergence correction, substantially as herein described with reference to Figures 3 to 16 of the accompanying drawings.

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