

PATENT SPECIFICATION

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(54) APPARATUS FOR READING VIDEO- AND/OR AUDIO
 SIGNALS BY OPTICAL MEANS

(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 This invention relates to apparatus for reading optically an information carrier of disc form provided with parallel tracks in which sound and/or video signals are stored. (The term "parallel tracks" is to be understood to mean a number of tracks constituting the successive turns of a spiral or a number of separate circular concentric tracks).

15 An apparatus of this type is described in Patent Specifications 1,146,843 and 1,146,844. In the known apparatus a beam of radiation is directed through the information carrier and the beam which emerges from the information carrier is focussed by an optical imaging system onto a reflective element which comprises two reflective surfaces disposed at an acute angle. The radiation beam incident on the reflective element is divided into two sub-beams each of which are applied to a radiation-sensitive detector cell. The electric output signals of the detector cells are compared with one another and the difference signal is used for positioning the read means relative to the information track. Both a coarse control and a fine control are achieved by means of the same difference signal. The coarse control effects radial control of a read system accommodated in a casing along the information track. The fine control relates to the alignment of the reflective element relative to the information track.

In the known apparatus the accuracy and insensitivity to interference of the radial con-

45 trol are not satisfactory. Furthermore the known apparatus is limited to the control of radial movements of the information carrier relative to the optical imaging system. Moreover non-uniform spatial intensity distribution in the radiation emitted by the source is not allowed for.

50 It is an object of this invention to provide improved read apparatus of the type set forth which can give an accurate indication of a axial and/or radial displacements of the optical imaging system relative to the information carrier, and can be rendered insensitive to spatial variations in the intensity of the radiation used.

55 The invention provides apparatus for reading optically an information carrier of disc form comprising parallel information tracks (as defined) containing video and/or sound information recorded in optically readable form, the apparatus comprising:

60 (a) optical means for directing a read beam of radiation at a region of the disc including parts of a number of tracks on either side of a desired track which is to be read,

(b) means for rotating the disc in a plane which intersects the path of said beam,

70 (c) means for imaging beam radiation from said region of the disc in, or substantially in, an image plane containing the radiation-receiving aperture of a radiation-sensitive pick-up cell provided for converting a part of the read beam modulated by the information in said desired track into electrical video and/or sound signals, the said plane being referred to herein as the pick-up plane and said imaging radiation as the imaging beam, and

80 (d) a control system, said system including grating means consisting of alternate parallel radiation-transmitting and radiation-absorbing stripes and positioned in the path of said

imaging beam, said alternate stripes being at substantially the same pitch and substantially parallel to the tracks of the disc-region image, radiation-sensitive detector means for converting radiation from said grating means into electric signals, means for deriving from said signals a positional error signal, and means responsive to said error signal for controlling the relative position of the said disc region image and said pick-up plane.

The control system may be used in known manner for radially displacing the read beam across the information track and/or displacing the plane in which the image of the wanted portion of the information track is produced, i.e. tracking and/or focus can be corrected. In apparatus according to this invention use is made of the fact that adjacent track portions of the disc together form a grating which, for a small area, is substantially rectilinear. Thus, apparatus according to this invention is based on a principle different from that of the known apparatus and has the advantage that, by the use of a region of the information carrier or disc containing a number of tracks, a greater amount of radiation is available so that a better signal-to-noise ratio is obtained for control purposes.

Herein the term "grating" includes a virtual grating when viewed as a virtual image of an actual grating e.g. in a plane mirror and/or through a plate of refractive material.

The grating and detector means may comprise two gratings which lie in said pick-up plane or lie in planes located on opposite sides thereof and a radiation-sensitive detector behind each grating, the means for deriving an error signal being adapted to operate by comparing the signals from said detectors. This permits the system to provide the sign of an error signal as well as its amplitude.

In the latter case the gratings may lie on opposite sides of the pick-up plane in such positions as to intercept different cross-sectional parts of the imaging beam, the means responsive to the error signal being adapted to employ said error signal as a focussing error signal by moving said disc-region image along the imaging beam axis towards coincidence with said pick-up plane.

Alternatively the gratings may be co-planar and lie substantially in said pick-up plane with a mutual phase-shift of about 180° , the means responsive to the error signal being adapted to employ said error signal as a tracking error signal by moving said disc-region image in a direction normal to the imaging beam axis until the part of said image corresponding to a desired track is centred on said pick-up cell.

In the latter case, the two gratings may be placed on opposite sides of the imaging beam axis. Alternatively the two gratings may both extend across the imaging beam axis and consist of two interleaved sets of stripes adapted to transmit light of two different colours,

each detector being arranged to respond mainly or substantially only to one of said colours.

As will be explained, an automatic focus control system in accordance with the invention may be combined with an automatic tracking control system in accordance with the invention so that errors of both kinds are corrected.

As a modification of the invention a grating with its associated detector can be replaced by a radiation-sensitive detector of comb or grid form. In particular, two interleaved gratings (each with its detector) can be replaced by a pair of such comb-shaped detectors with their stripes or "teeth" interleaved.

Apparatus in accordance with the invention may be rendered insensitive to spatial variations in the intensity of the radiation used. This may be obtained by placing a beam splitter in the path of the radiation beam transmitted or reflected by the information carrier and by placing a grating in the path of each sub-beam produced by the beam splitter, which gratings are spaced from the beam splitter by different distances. The apparatus can be rendered insensitive to inhomogeneities in the gratings by so arranging the gratings with respect to one another that the stripes of the two gratings when projected on to the plane of the information carrier are aligned, so that when reading the information carrier the image of the information grating is successively swept over the gratings (the expression "information grating" will be used to refer to the illuminated region of the disc since the latter is treated as an additional grating by the beam control system; of course, in addition a small, preferably central, part of said region is utilized by the pick-up cell to obtain the desired video and/or sound signals from the one track which is being read).

Embodiments of this invention will now be described by way of example, with reference to the accompanying diagrammatic drawings in which:—

Figures 1 and 11 and Figure 6 respectively show read apparatus provided with means for detecting displacements of the optical imaging system relative to the information track in the axial direction (for focus control) and radial direction (for tracking control);

Figures 3 and 4 and Figure 7 show gratings for use in the apparatus shown in Figure 1 and Figure 6 respectively;

Figure 5 and Figure 8 show how the apparatus shown in Figure 1 and Figure 6 respectively may be rendered independent of spatial variations in the intensity of the beam of radiation;

Figures 9, 10 and 12 show other grating arrangements, and

Figure 2 shows part of an information track in schematic form.

In the Figures corresponding elements are designated by like reference numerals.

In Figure 1 reference numeral 1 denotes an information carrier of disc form and its tracks are described as the turns of a single spiral track though the latter can be replaced by a series of concentric circular tracks. Figure 2 is a plan view of a small part of four turns r of an information track. An arrow 15 indicates the direction in which the information carrier is moved. The turns r of the information track comprise areas g in which the information is stored. The turns r are separated by spacings O . The mean period a in the track direction is, say, $4\ \mu\text{m}$. The width b of the track also may be, say, $4\ \mu\text{m}$. The track pitch c in the radial direction is, say, $6\ \mu\text{m}$.

The information track may have a phase structure or an amplitude structure, that is to say it may change the phase or the amplitude of the radiation of a read beam falling on it. It is possible to transmit the read beam through the information plate or to reflect the beam from the plate. For the sake of simplicity the embodiments of the invention are described only with reference to an information carrier with alternate radiation-transmitting and radiation-absorbing areas. The embodiments to be described, however, may also be used for discs having tracks with reflection-structures and phase-structures.

In the apparatus shown in Figure 1 the information carrier is rotated by means of a spindle 3 which is driven by a motor, not shown, and which passes through a central opening 2 in the information carrier. Radiation emitted by a source 4 is concentrated into a read beam by a mirror 5. The beam 20 is reflected by a plane mirror 6 towards the information carrier 1. A lens 7 is arranged between the mirror 6 and the information carrier and focusses the read beam 20 onto a desired part of the information track. An imaging beam of radiation 21 transmitted by the information carrier 1 is reflected by a plane mirror 9 towards a pick-up or signal detector cell 10. The entire read system may be accommodated in a casing 13 which may be moved in the directions indicated by arrows 14, enabling the information carrier to be radially scanned.

Owing to, for example, inaccuracies in the supporting system of the information carrier 1 or the casing 13 or to warping of the information carrier, the information track may perform unwanted horizontal and vertical movements. To enable the latter movements to be detected, the apparatus of Figure 1 is provided with a control system including two gratings 11 and 12 each made of alternating radiation-transmitting and radiation-absorbing stripes. The dimensions of the read beam 20 which emerges from the lens 7 are such that it illuminates a region of the information carrier

which is much wider than the width of a turn of the information track. For example, the illuminated region may have the form of a circle of diameter $300\ \mu\text{m}$. Thus, in addition to the track turn which is to be read (for example the track turn r' in Figure 2) about 25 turns r on the left and on the right of r' are also illuminated.

The adjacent stripes r and O of the information track together form a grating which may be considered to be substantially rectilinear in the illuminated region. An objective lens 8 forms a magnified image of this grating, this being the disc-region image previously referred to. This will be explained with reference to Figure 3 which is a perspective view of the gratings.

A grating A represents part of the information track of the disc and is the object on which the read beam is to be focussed. The pitches of the gratings 11 and 12 correspond to that of the track grating magnified N times by lens 8. The rays shown schematically in the drawing lie in a vertical plane indicated by a dotted line down the centre of grating A which plane contains the axis of the imaging beam 21, and gratings 11 and 12 lie on opposite sides of said plane and extend orthogonally therefrom. When the image of the object or information grating A coincides with the grating 11, the amount of radiation which emerges from the grating 11 is a limit amount (maximum or minimum) so that a first radiation detector (not shown) arranged behind the grating 11 will deliver an electric signal of limit value for control purposes. A second radiation detector cell (also not shown) placed behind the grating 12 delivers a signal which is different from the said limit value. If the image of the grating A formed by the lens 8 is shifted towards the grating 12, the current of the detector placed behind the grating 12 will approach the limit value whilst that of the detector placed behind the grating 11 will depart from the limit value. If the image of the grating A is midway between the gratings 11 and 12, the currents of the first and second detectors are equal. The difference between the currents of the detectors arranged behind the gratings 11 and 12 thus may be used to measure deviations in focussing with respect to a pick-up plane 15 midway between the gratings 11 and 12 in which plane the effective aperture of the cell 10 is located.

The difference signal produced may be used as a focus error signal and applied to a mechanism which in a known manner controls the lens 8 so as to always return its image plane to the plane 15 midway between the gratings 11 and 12. In the plane 15 is arranged the signal (audio and/or video) detector cell 10 capable of detecting the luminous variations in the radiation beam which are due to the interaction of the beam with the selected

turn of the information track lying at the centre of the illuminated region.

Figures 1 and 3 show two gratings comprising radiation-transmitting and radiation-absorbing stripes and, as aforesaid, a radiation-sensitive detector (not shown) is arranged behind each grating. It is also possible for these detectors and gratings to be combined as a configuration of alternate radiation-sensitive and radiation-insensitive stripes e.g. as shown in Figure 9. This saves space, and an optical system for producing an image of the grating on the detector cell may be dispensed with. This also applies to other gratings to be described hereinafter.

Figure 3 shows a situation in which two actual gratings 11 and 12 are physically spaced from one another. As an alternative, however, the system may employ two virtual gratings derived from a single actual grating with a glass plate arranged in front of one of the grating parts, as is shown in Figure 4. In Figure 4 reference numeral 16 denotes the actual grating. A glass plate 17 is arranged in front of the upper part of this grating. As a result, an observer W sees this grating part as a virtual grating 11 which is shifted towards the observer with respect to the grating 16. The lower part of the grating 16 is observed as a grating 12 in the same plane as the grating 16. The dot-dashed line 18 indicates the pick-up plane in which the signal detector cell is positioned. Obviously, as an alternative glass plates of different thicknesses may be placed before both parts of the grating 16. Also, the plates may be made of radiation-transmitting material other than glass.

In the grating arrangements described, the various grating parts are struck by different parts of the radiation beam. If the intensity of the beam varies across its cross-sectional area, the beam parts passing through the gratings 11 and 12 may have different intensities, even if the image plane of the information grating lies midway between the gratings 11 and 12. Erroneous detection owing to spatial intensity variations in the radiation beam can be avoided by using an arrangement as shown in Figure 5a.

Two inclined semi-transparent mirrors 30 and 31 are inserted in the path of the radiation beam 21 towards the gratings 11 and 12 respectively. As a result, parts of the radiation are directed as beams 22 and 23 to reference detectors 32 and 33 respectively. The remainder of the radiation reaches detectors 34 and 35 as beams 24 and 25 respectively. The ratio of the electric output signals of the detectors 32 and 34 and that of the detectors 33 and 35 are electronically determined. The signals

which depend only on the locations of the gratings 11 and 12 relative to the image plane may then be compared with one another.

Figure 5b shows a second arrangement which is insensitive to spatial variations in the radiation beam. The radiation beam 21 from the information carrier is divided into two sub-beams by a beam-splitting mirror 50. Gratings 11 and 12 are each inserted in the path of one of the sub-beams. The gratings 11 and 12 are spaced by different distances from the beam splitter. Thus, the information grating is imaged on the two component gratings by two beams having the same spatial intensity distribution.

The apparatus may also be rendered insensitive to inhomogeneities in the gratings. For this purpose the two gratings 11 and 12 may be aligned so that the directions of length of the stripes coincide as shown in Figure 5c. When the information carrier is read its image is moved over the gratings in the direction indicated by an arrow 53, so that these gratings are successively struck by radiation beams having the same spatial intensity distribution.

Figure 6 shows schematically a read apparatus provided with means for detecting the radial position of the read beam relative to the information carrier for the purpose of ensuring correct tracking. This apparatus is similar to that shown in Figure 1. However, instead of two gratings of radiation-transmitting and radiation-absorbing stripes arranged one on either side of the pick-up plane of the signal detector cell, a single grating 36 is positioned in this plane. An image of an information grating (corresponding to grating A of Figure 3) is formed on the said grating by the lens 8. When the radiation-absorbing stripes of the grating 36 coincide with the dark stripes of the image of the information grating formed by the lens 8, the amount of radiation incident on a detector placed behind the grating 36 has a maximum value. When the dark stripes of the image of the information grating screen off the radiation-transmitting stripes of the grating 36, the amount of radiation incident on the said detector is at a minimum. By electronically measuring the output signal from the detector it may be ascertained whether the read beam is correctly positioned radially with respect to the turns of the information track. The output signal may be used as an error signal to actuate means (not shown) for displacing the read beam in a radial direction across the information track in a known manner.

In order to also determine the sign of a positional deviation of the read beam relative to the information track, the grating preferably takes the form of two coplanar gratings the stripes of which are shifted relative to one another. Figure 7a is a front elevation of part of such a pair of gratings. Grating 36a has

$$S_A = \frac{S_{34}}{S_{33}} \text{ and } S_B = \frac{S_{35}}{S_{33}}$$

the same structure as grating 36b except that the positions of the radiation-transmitting and the radiation-absorbing stripes are interchanged in the two gratings. When an image 37 of the information grating occupies the position shown in Figure 7b relative to the gratings, the radiations which emerge from the gratings 36a and 36b will have equal intensities. When the image grating 37 is displaced upwards, the amount of radiation transmitted by the grating 36a will be reduced and that transmitted by the grating 36b will be increased. The converse will occur when the image grating 37 is shifted downwards. By comparing the values of the electric output signals from detectors (not shown) arranged behind the two gratings, the direction of any deviation can be found.

The apparatus shown in Figure 6 may be made independent of spatial variations in the intensity of the radiation beam in the manner described with reference to Figures 5a and 5b. However, this independence may alternatively be achieved by arranging a birefringent element (e.g. a quartz plate 38 having an optic axis 38a at an angle of 45° to the major surfaces) in front of the grating 36, as is shown in Figure 8a. The radiation beam 21 incident on the quartz plate 38 is divided by it into two sub-beams which are polarized at right angles to one another and are mutually shifted through a small distance in a direction at right angles to the direction of the incident beam. Thus, there are produced in the plane of the grating 36 two images of the information grating which are mutually shifted by one half of a grating spacing. Behind the grating 36 is arranged an element 39 which in accordance with the direction of polarisation either reflects the radiation towards a detector 40 or transmits it towards a detector 41. Instead of a quartz plate a Wollaston prism or a Savart plate may be used as the element 38.

Instead of using plane polarisation, two sub-beams may be distinguished by colour, for which purpose the system may use two component gratings which are differently coloured, as is shown in Figure 8b. The component grating 36b (shown in full lines) transmits, for example, red light only, whilst the component grating 36a (shown in broken lines) transmits blue light only, the component gratings being interlaced, thus the radiation-transmitting stripes of the grating 36b may act as, and be situated at the locations of, the notional radiation-absorbing stripes of the grating 36a, and *vice versa*. A colour separating element, such as a colour-selective mirror 39, is arranged behind the gratings 36a—36b and reflects a beam of one colour to a detector 40 and transmits a beam of the other colour to a detector 41.

If grating-shaped radiation detectors are used, they may have a comb-shaped configuration. In this event they may be inter-

digitated, as is shown in Figure 9. The radiation-sensitive stripes of the component grating 36a are situated between the radiation-sensitive stripes of the component grating 36b and *vice versa*. Thus the two component gratings are illuminated by the same radiation beam. The arrangements illustrated in Figures 8b and 9 have also the advantage that the effective radiation-sensitive surface area is about twice that obtained when separate gratings are placed side by side. Hence, with the same amount of light a signal of about double magnitude can be obtainable at the outputs of the detectors. A grating system 36 may also be divided into a large number of component gratings 36a and 36b the grating stripes of horizontally and vertically adjacent component gratings being shifted e.g. as shown in Figure 10 which is a front elevation of such a grating structure. The component gratings 36a and 36b are distributed over the entire cross-sectional area of the beam of radiation, so that spatial variations in radiation intensity are averaged out.

Reverting to the focus control problem, it is also possible to use a grating placed in the plane of the signal detector cell for detecting displacements of the plane in which the part of the information carrier to be read is imaged. For this purpose the magnification of the lens 8 is utilised. This will be explained more fully with reference to Figure 11.

A magnified image of the information grating A is produced by lens 8. If the grating A is correctly positioned, the image B of this grating is formed in the plane of a grating C situated in the plane of the signal detector cell. Behind the grating C there are arranged at least three detectors (not shown) one of which intercepts the radiation from the centre part of the grating C, whilst the other two intercept radiation from the edges of the grating C. The pitches of image B and grating C are equal and their stripes are oriented in a manner such that the detectors placed behind the grating C deliver a given signal. If the information grating is shifted to the left (A'), the grating pitch of the image B' of the shifted information grating A' will be smaller than that of C, and in addition B' is now spaced from C. When the information grating is shifted to the right a converse situation is obtained. Thus, the amount of radiation incident on the detectors arranged behind the grating C depends upon the distance between the lens 8 and the information grating.

Such a grating for detecting displacements of the image plane may be combined with a grating for detecting radial displacements of the read beam relative to the information carrier.

Gratings for detecting changes in the position of the image plane (the optical path lengths between each of these gratings and the information carrier being different) may

also be combined with a grating for detecting radial displacements of the information carrier relative to the optical imaging system, e.g. as is shown in Figure 12a. The assembly comprises a grating 42 two parts of which are covered by glass plates 43 and 44 of different thicknesses, whilst a third part remains uncovered. An observer then will see the grating part behind the plate 43 as a virtual grating 11 and the grating part behind the plate 44 as a virtual grating 36. The uncovered part of the grating 42 is observed as a grating 12. The grating 36, which serves to detect deviations in a radial direction, lies midway between the planes of the gratings 11 and 12 which serve to detect vertical deviations. The grating 36 may take the form of two component gratings 36a and 36b with mutually phase-shifted grating stripes. This grating 36 may occupy one half of the surface area of the grating 42. For this purpose this half is covered by a thin glass plate (see Figure 12b). One half of the remainder of the grating is covered by a thick glass plate 43 and the other half remains uncovered. Broken lines 54 indicate how an image of the information grating is formed on the grating 42. An arrow 55 indicates how the image grating 54 moves over the grating 42 when the information carrier is read.

WHAT WE CLAIM IS:—

1. Apparatus for reading optically an information carrier of disc form comprising parallel information tracks (as defined) containing video and/or sound information recorded in optically readable form, the apparatus comprising;

(a) optical means for directing a read beam of radiation at a region of the disc including parts of a number of tracks on either side of a desired track which is to be read,

(b) means for rotating the disc in a plane which intersects the path of said beam,

(c) means for imaging beam radiation from said region of the disc in, or substantially in, an image plane containing the radiation-receiving aperture of a radiation-sensitive pick-up cell provided for converting a part of the read beam modulated by the information in said desired track into electrical video and/or sound signals, the said plane being referred to herein as the pick-up plane and said imaging radiation as the imaging beam, and

(d) a control system, said system including grating means consisting of alternate parallel radiation-transmitting and radiation-absorbing stripes and positioned in the path of said imaging beam, said alternate stripes being at substantially the same pitch and substantially parallel to the tracks of the disc-region image, radiation-sensitive detector means for converting radiation from said grating means into electric signals, means for deriving from said signals a positional error signal, and means

responsive to said error signal for controlling the relative position of the said disc region image and said pick-up plane.

2. Apparatus as claimed in Claim 1 wherein said grating and detector means comprise two gratings which lie in said pick-up plane or lie in planes located on opposite sides thereof and a radiation-sensitive detector behind each grating, and wherein the means for deriving an error signal are adapted to operate by comparing the signals from said detectors.

3. Apparatus as claimed in Claim 2 wherein the gratings lie on opposite sides of the pick-up plane in such positions as to intercept different cross-sectional parts of the imaging beam and wherein the means responsive to the error signal are adapted to employ said error signal as a focussing error signal by moving said disc-region image along the imaging beam axis towards coincidence with said pick-up plane.

4. Apparatus as claimed in Claim 2 wherein the gratings are co-planar and lie substantially in said pick-up plane with a mutual phase-shift of about 180° and wherein the means responsive to the error signal are adapted to employ said error signal as a tracking error signal by moving said disc-region image in a direction normal to the imaging beam axis until the part of said image corresponding to a desired track is centred on said pick-up cell.

5. Apparatus as claimed in Claim 4 wherein the two gratings are placed on opposite sides of the imaging beam axis.

6. Apparatus as claimed in Claim 4 wherein the two gratings both extend across the imaging beam axis and consist of two interleaved sets of stripes adapted to transmit light of two differing colours, each detector being arranged to respond mainly or substantially only to one of said colours.

7. A modification of the apparatus claimed in any preceding claim wherein the or each grating with its associated detector is replaced by a radiation-sensitive detector of comb or grid form.

8. Apparatus substantially as described with reference to Figure 1 or Figures 1 and 3 of the accompanying drawings.

9. Apparatus substantially as described with reference to Figure 1 as modified by Figure 4 of the accompanying drawings.

10. Apparatus substantially as described with reference to Figure 1 as modified by Figure 5a or Figure 5b or Figure 5c of the accompanying drawings.

11. Apparatus substantially as described with reference to Figure 6 of the accompanying drawings.

12. Apparatus substantially as described with reference to Figure 6 as modified by Figures 7a and 7b of the accompanying drawings.

13. Apparatus substantially as described

also be combined with a grating for detecting radial displacements of the information carrier relative to the optical imaging system, e.g. as is shown in Figure 12a. The assembly comprises a grating 42 two parts of which are covered by glass plates 43 and 44 of different thicknesses, whilst a third part remains uncovered. An observer then will see the grating part behind the plate 43 as a virtual grating 11 and the grating part behind the plate 44 as a virtual grating 36. The uncovered part of the grating 42 is observed as a grating 12. The grating 36, which serves to detect deviations in a radial direction, lies midway between the planes of the gratings 11 and 12 which serve to detect vertical deviations. The grating 36 may take the form of two component gratings 36a and 36b with mutually phase-shifted grating stripes. This grating 36 may occupy one half of the surface area of the grating 42. For this purpose this half is covered by a thin glass plate (see Figure 12b). One half of the remainder of the grating is covered by a thick glass plate 43 and the other half remains uncovered. Broken lines 54 indicate how an image of the information grating is formed on the grating 42. An arrow 55 indicates how the image grating 54 moves over the grating 42 when the information carrier is read.

WHAT WE CLAIM IS:—

1. Apparatus for reading optically an information carrier of disc form comprising parallel information tracks (as defined) containing video and/or sound information recorded in optically readable form, the apparatus comprising;
 - (a) optical means for directing a read beam of radiation at a region of the disc including parts of a number of tracks on either side of a desired track which is to be read,
 - (b) means for rotating the disc in a plane which intersects the path of said beam,
 - (c) means for imaging beam radiation from said region of the disc in, or substantially in, an image plane containing the radiation-receiving aperture of a radiation-sensitive pick-up cell provided for converting a part of the read beam modulated by the information in said desired track into electrical video and/or sound signals, the said plane being referred to herein as the pick-up plane and said imaging radiation as the imaging beam, and
 - (d) a control system, said system including grating means consisting of alternate parallel radiation-transmitting and radiation-absorbing stripes and positioned in the path of said imaging beam, said alternate stripes being at substantially the same pitch and substantially parallel to the tracks of the disc-region image, radiation-sensitive detector means for converting radiation from said grating means into electric signals, means for deriving from said signals a positional error signal, and means

responsive to said error signal for controlling the relative position of the said disc region image and said pick-up plane.

2. Apparatus as claimed in Claim 1 wherein said grating and detector means comprise two gratings which lie in said pick-up plane or lie in planes located on opposite sides thereof and a radiation-sensitive detector behind each grating, and wherein the means for deriving an error signal are adapted to operate by comparing the signals from said detectors.

3. Apparatus as claimed in Claim 2 wherein the gratings lie on opposite sides of the pick-up plane in such positions as to intercept different cross-sectional parts of the imaging beam and wherein the means responsive to the error signal are adapted to employ said error signal as a focussing error signal by moving said disc-region image along the imaging beam axis towards coincidence with said pick-up plane.

4. Apparatus as claimed in Claim 2 wherein the gratings are co-planar and lie substantially in said pick-up plane with a mutual phase-shift of about 180° and wherein the means responsive to the error signal are adapted to employ said error signal as a tracking error signal by moving said disc-region image in a direction normal to the imaging beam axis until the part of said image corresponding to a desired track is centred on said pick-up cell.

5. Apparatus as claimed in Claim 4 wherein the two gratings are placed on opposite sides of the imaging beam axis.

6. Apparatus as claimed in Claim 4 wherein the two gratings both extend across the imaging beam axis and consist of two interleaved sets of stripes adapted to transmit light of two differing colours, each detector being arranged to respond mainly or substantially only to one of said colours.

7. A modification of the apparatus claimed in any preceding claim wherein the or each grating with its associated detector is replaced by a radiation-sensitive detector of comb or grid form.

8. Apparatus substantially as described with reference to Figure 1 or Figures 1 and 3 of the accompanying drawings.

9. Apparatus substantially as described with reference to Figure 1 as modified by Figure 4 of the accompanying drawings.

10. Apparatus substantially as described with reference to Figure 1 as modified by Figure 5a or Figure 5b or Figure 5c of the accompanying drawings.

11. Apparatus substantially as described with reference to Figure 6 of the accompanying drawings.

12. Apparatus substantially as described with reference to Figure 6 as modified by Figures 7a and 7b of the accompanying drawings.

13. Apparatus substantially as described



with reference to Figure 6 as modified by Figure 8b of the accompanying drawings.

14. Apparatus substantially as described with reference to Figure 6 as modified by 5 Figure 8b of the accompanying drawings.

15. Apparatus substantially as described with reference to Figure 6 as modified by Figure 9 of the accompanying drawings.

16. Apparatus substantially as described 10 with reference to Figure 6 as modified by Figure 10 of the accompanying drawings.

17. Apparatus substantially as described :

with reference to Figure 1 as modified by Figure 11 of the accompanying drawings.

18. Apparatus substantially as described 15 with reference to Figures 1 and 6 as modified by Figures 12a or 12b of the accompanying drawings.

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