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(54) APPARATUS FOR READING DISK-SHAPED RECORDS

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, EC2V 8AH, 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:—

The invention relates to apparatus for reading a disk-shaped record on which information is recorded in optically coded form in a number of parallel tracks constituting the successive turns of a spiral or a number of separate circular concentric tracks, defined herein as tangentially extending tracks, which apparatus comprises a radiation source for producing a read beam of radiation, a tracking system for ensuring that a scanning spot caused by said read beam on the record follows a desired track, a read detector for converting the information contained in said read beam after cooperation with the record into an electrical signal, a measuring detector for measuring the radial position of the scanning spot relative to the desired track and supplying a corresponding control signal to the tracking system, and a switching device for causing the scanning spot to jump from any given scanned track to an adjacent track in response to a start signal which is supplied by a command device, which switching device comprises a signal source for supplying to the tracking system a control signal suitable for causing such a jump which control signal comprises two consecutive signal periods of substantially the same duration and substantially the same shape, but of opposite polarity.

Disk-shaped records of the type mentioned in the preamble are, for example, suitable as a recording medium for a television signal. Said television signal is then usually recorded in spiral tracks which is scanned continuously during normal reading. These records however, may also

be employed for storing other types of information, for example audio information only; in this case a very long playing time is attainable with the aid of, for example, time or frequency multiplex techniques. Alternatively, such a record may be used to advantage as a storage medium for personal data, x-ray images and the like. For these last mentioned applications the record will generally be provided with concentric tracks instead of spiral tracks.

The use of optical coding and an associated optical read system has the major advantage that the scanning spot can be moved freely on the record, without damaging the record. This opens up important additional possibilities for the use of this type of record. For example, this enables the ultimate reproducing speed of the recorded information to be varied at will during read-out of a television signal which is recorded on such a record. In the case of a record on which said television signal is recorded in spiral tracks forming parts of a continuous spiral, it is for example possible to realise a still picture during reproduction by causing the scanning spot to jump radially backwards over one track distance after every revolution of the record, so that during the desired time always one and the same track is scanned. In order to realise "slow motion" at for example half the normal speed of movement, the scanning spot can be moved radially backwards over one track distance after every two revolutions of the record. If the record has a number of concentric tracks instead of spiral tracks it is necessary for the read apparatus to incorporate means which enable the scanning spot to jump from track to track in a radial direction.

Read apparatus of the type mentioned in the preamble, including such a means is described in Patent Specification 1,429,882. The tracking system incorporated in the read apparatus according to said Patent Specification comprises a beam deflection means disposed in the read beam of

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radiation, usually a mirror which can be tilted so as to produce a displacement of the scanning spot in a radial direction, i.e. perpendicular to the track direction. Said beam deflection means forms part of a control system which further includes the measuring detector, said control system ensuring that the scanning spot always remains correctly positioned on the desired track despite changes of the radial position of the tracks.

In order to enable the scanning spot to jump from a track which is being scanned to an adjacent track, said known apparatus includes a switching device, which, after a start signal supplied by a command device, interrupts the control loop formed by the control system and then supplies to the beam-deflection means a control signal suitable for causing the jump of the scanning spot. For this purpose this control signal consists of two consecutive signal periods of substantially the same duration and substantially the same predetermined shape but of opposite polarity. It is obvious that the duration and the shape of said control signal are selected so that this control signal causes a displacement of the scanning spot equal to the nominal track pitch.

For a correct reproduction of the recorded information after such a jump or displacement of the scanning spot has been performed, it is of course of particular importance that after said displacement the scanning spot accurately coincides with the new desired track. However, it has been found that in this respect a number of factors play a part which cannot be controlled entirely. For example, the track pitch is subject to tolerances which occur during manufacture of the record, so that said track distance varies both as a function of the radial position on the record and from record to record. If the actual track distance deviates from the nominal value, it is evident that when the scanning spot of the known apparatus has effected a jump, there will be a residual positional error relative to the new desired track, so that it may even happen that the scanning spot is not pulled in on this track by the control system.

Furthermore, the effect of the control signal depends on the initial values, i.e. the positional error of the scanning spot relative to the track being scanned at the beginning of this control signal and the radial speed of the scanning spot which then obtains. Depending on these initial values, both final positional errors and final speed errors may arise upon termination of the control signal, so that pulling in on the desired track is impaired.

Moreover, final positional errors may occur if the natural resonant frequency of

the beam deflection means deviates from the frequency which corresponds to the speed of the record, which final error is then caused by the movement of the beam-deflection means itself during the control signal.

It is an object of the present invention to provide apparatus of the type referred to in the preamble, in which provision has been made to mitigate the above mentioned problems and to ensure correct track-jumping of the scanning spot. For this purpose, the invention provides apparatus for reading a disc-shaped record on which information is recorded in optically coded form in tangentially extending tracks, as defined hereinbefore, which apparatus comprises a radiation source for producing read beam of radiation, a tracking system for ensuring that a scanning spot produced by said read beam on the record follows a desired track, a read detector for converting the information contained in said read beam after cooperation with the record into an electrical signal, a measuring detector for supplying a tracking measuring signal giving the radial position of the scanning spot relative to the desired track and supplying a corresponding tracking control signal to the tracking system, and a switching device for causing the scanning spot to jump from any given scanned track to an adjacent track in response to a start signal which is supplied by a command device, which switching device comprises a signal source for supplying to the tracking system a jump control signal suitable for causing such a jump which jump control signal comprises two consecutive signal periods of substantially the same duration and substantially the same shape, but of opposite polarity, characterized in that the switching device includes a detection circuit for detecting the instant at which the scanning spot is located half-way between the two adjacent tracks during a jump and for supplying at that instant a detection signal to the signal source, and in that said signal source is adapted to supply the jump control signal as a signal whose two signal periods each have a duration which automatically substantially equals the time interval between the start signal and the detection signal.

The invention ensures in a simple manner that the control signal is automatically adapted to the varying track distance and the initial values. This has the major advantage that the requirements with respect to the tolerances of the quantities which are of interest for trackjumping, such as the track distance, the resonant frequency of the beam-deflection means and the like, can be reduced considerably. Examples of apparatus embodying the

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invention will be described with reference to the accompanying drawings, in which:

Figure 1 shows one form of the known read apparatus,

5 Figure 2 illustrates an example of a method used therein for generating a suitable signal for measuring the radial position of the scanning spot,

10 Figure 3 shows a number of signals which appear in the known apparatus during track jumping of the scanning spot.

Figure 4 shows a first example of the switching device used in read apparatus in accordance with the invention, and

15 Figures 5a—g show a number of signals which occur in the device of Figure 4 during jumps of the scanning spot.

Figure 6 shows a second example of the switching device, and

20 Figure 7 shows the associated signals, whilst

Figures 8 and 9 show two further examples.

25 Figure 1 shows a disk-shaped record 1 which is rotated by a motor 2 with the aid of a supporting spindle 4 which extends through a central opening 3 of the record 1. This record 1 comprises either consecutive spiral tracks or a multitude of concentric tracks, on which information is recorded in optically coded form. The specific embodiment of this record carrier, i.e. a rigid disk or foil, the method of optical coding, for example an embossed pattern or a black-white pattern and the method of signal coding are of no interest for the present invention, so that these will not be discussed in more detail. For illustration reference is made to Patent Specifications 30 1,391,541, 1,387,304, 1,446,009, 1,489,757, 1,489,756, 1,529,954, 1,530,811 and 1,530,812 in which examples of records and methods of optical coding are described.

35 The information recorded on the record 1 is read with the aid of an optical read system which is accommodated in a housing 5. This read system first of all comprises a radiation source 6 which emits a radiation beam *a*. Said radiation beam *a* is directed via a semi-transparent mirror 7 and a mirror 8 to the record 1 and with the aid of a lens 11 it is focussed on the surface of said record on which the information is recorded. In the present instance this is the reflecting upper surface, the medium of the record of course being light-transmitting. The radiation beam which has been modulated by the information of said record is reflected by the upper surface of the record 1 and via the 40 lens 11, the mirror 8 and the semi-transparent mirror 7 it is directed to a read detector 12. As a result, the point of incidence A of the beam of radiation on the record, the scanning spot is imaged on this 65 read detector 12. This read detector 12

converts the recorded optical information into an electric signal which is then available at an output terminal 13 for further processing, such as decoding.

70 In order to enable the information recorded on the record 1 to be read, the optical read system should include a tracking control device which ensures that the scanning spot A always coincides with an information track. This tracking control device, which consequently controls the radial position of the scanning spot A, should first of all be capable of following variations of the radial position of the tracks due for example to eccentricity of the 75 central opening 3. If the record 1 has spiral tracks, forming parts of a continuous spiral, this scanning spot A should be moved in a radial direction over a distance which corresponds to the pitch of this spiral during every revolution of the record carrier. 80 85

This necessary control of the radial position of the scanning spot is achieved with the aid of a tracking system which comprises the mirror 8. This mirror 8 is 90 pivotable and can be tilted around a spindle 9 with the aid of drive means 10, so that the deflection of the radiation beam *a* (and thus the radial position of the scanning spot A) can be modified. The tracking control signal required for this drive means is supplied by a control amplifier 15 which receives a tracking measuring signal I from a measuring detector 14. This measuring 95 detector 14 cooperates with a radiation beam *b*, which is emitted by the radiation source 6 parallel to the radiation beam *a* and which (after cooperation with the record 1) is incident on the measuring detector 14. This combination of a radiation beam *b* and measuring detector 14 should then of course supply a measuring signal I which is representative of the position of the scanning spot A relative to the desired track. 100 105 110

From the literature various systems are known which supply such a measuring signal. For example in Patent Specifications 1,391,335 and 1,434,834 two systems are described in which a suitable measuring 115 signal is obtained by a suitable combination of radiation beam (*b*) shape i.e. the pattern of radiation spots produced on the record by this beam, and type of measuring detector 14. From United States Patent Specification 3,381,086 and German Patent Application 2,342,906 two systems are known in which the measuring signal is directly derived from the read beam of radiation *a*, so that in said systems no additional radiation beam *b* need be used. From Patent Specification 1,489,757 a system is also known in which no additional radiation beam *b* is required, but where the 120 125 130 measuring signal can be derived from the

beam of radiation in that the tracks on the record are provided with a fixed periodic pattern of undulations in a radial direction. The measuring signals ultimately obtained with the aid of these cited systems, however, exhibit no basic differences and may therefore each be used as such in apparatus embodying the present invention.

To illustrate the variation of this measuring signal I, Fig. 2 schematically represents the system as described in the cited Patent Specification 1,434,834. In this system the radiation beam *b* consists of two sub-beams so that two radiation spots *B*₁ and *B*₂ are projected on the record. These two radiation spots *B*₁ and *B*₂ are located at either side of the scanning spot *A* as regards their radial positions, whilst their radial shifts relative to this scanning spot are $\frac{1}{2}P$, *P* being the nominal track pitch. Fig. 2a shows the positioning of these radiation spots *B*₁ and *B*₂ and the scanning or reading spot *A* in the situation that the scanning spot *A* correctly impinges on a track *Q*₁. Two further tracks *Q*₂ and *Q*₃ are also shown and these tracks *Q*₁, *Q*₂ and *Q*₃ may be concentric tracks or they may form part of a spiral.

In order to obtain the desired measuring signal I the measuring detector 14 is divided into two halves which each receive one of the two sub-beams corresponding to the radiation spots *B*₁ and *B*₂. The measuring signal I is then obtained from the difference between the output signals of these two detector halves. It is evident that in the situation shown in Fig. 2a, the reflection of the sub-beams at the location of the radiation spots *B*₁ and *B*₂ is equal, so that the measuring signal I which is ultimately obtained is zero. In order to indicate the variation of this measuring signal I when the scanning spot *A* (and thus the radiation spots *B*₁ and *B*₂) are moved in a radial direction, Fig. 2b shows the variation of the measuring signal I under the condition that the scanning spot *A* is moved in a radial direction with a constant speed *V*. The periodically varying (substantially sinusoidal) measuring signal I shown is then obtained, the period being equal to *P/V*. The instants denoted by *Q*₁, *Q*₂ and *Q*₃ then represent the instants at which the scanning spot *A* is centred on the tracks *Q*₁, *Q*₂ and *Q*₃ respectively. It is evident from this variation of the measuring signal that around these zero passages which correspond to the tracks *Q*₁, *Q*₂, *Q*₃ a measuring range exists in which the value and polarity of this measuring signal is a direct measure of the radial positional deviation of the scanning spot *A* relative to the relevant track. Once this scanning spot *A* cooperates with a certain track, this situation will be maintained owing to this

measuring signal and the beam-deflection means controlled by it.

As for practical reasons it is impracticable for the scanning spot *A* to scan the useful area of the record in a radial direction with the aid of the mirror 8 alone, the read apparatus of Fig. 1 comprises a second radial drive means which, for example consists of a worm 21 driven by a motor 20 which worm co-operates with a rack 22 secured to the housing 5. Thus the complete housing 5 with the optical read system can be moved in a radial direction. In the case of a record having spiral tracks the motor 20 may for example be operated at a constant speed. In a more sophisticated embodiment this motor 20 receives a radial drive control signal via control amplifier 19 which signal is derived from the angular position of the mirror 8. Thus the maximum deflection of the mirror 8 relative to its rest position remains limited irrespective of the desired radial movements of the scanning spot *A*.

As previously stated, the use of optical coding on the record and an optical read system has the advantage that the scanning spot may be moved over the record without damaging it. This in particular enables the scanning spot to jump from any given track to an adjacent track and thus provides the previously described extra degree of freedom as regards the method of reproducing the recorded information.

In order to achieve such track-jumping movements of the scanning spot it is possible to simply supply an additional jump control signal to the drive means 10 of the mirror 8, which jump control signal obviously should have such a variation that the mirror 8 is rotated through a predetermined angle which corresponds to a desired displacement of the scanning spot. For this purpose the jump control signal consists of two consecutive signal periods of the same duration and the same predetermined shape, but of opposite polarity.

Although this is not necessary *per se*, it is of advantage to ensure during such a jump control signal that the control loop (which is formed by the measuring detector 14, amplifier 15, drive means 10 and mirror 8) is interrupted. In Fig. 1 this is achieved by means of a switch 16. This switch 16 is normally in the position shown, the tracking control signal applied to the input 17 being fed from the control amplifier 15, to the drive means 10. This switch 16 is controlled by a switching device 23 which in its turn is controlled by a command device 24. This command device 24 receives command signals from a detection circuit 25, to which the read-out signal is applied, and which for example detects the vertical synchronizing

pulses of television signals read from the record. This command device may be activated manually by means of a button on the apparatus. After being activated this command device selects start signals for the switching device 23 from said synchronizing pulses, which device then changes over the switch 16 so that the said control loop is interrupted. Moreover, this switching device 23 then supplies the desired jump control signal from a signal source incorporated in the switching device 23 to the second input 18 of the switch 16, via which this jump control signal is then applied to the drive means 10. After the track-jumping displacement of the scanning spot A has been performed the switch 16 is then reset to the position shown. Examples of the switching device 23 and the command device 24 and possible control signals, therefore are comprehensively described in the aforesaid Patent Specification 1,429,882.

Fig. 3a by way of example shows a square-wave jump control signal which consists of a first positive pulse of duration T and amplitude K_a followed by a negative pulse of the same duration T and amplitude K_a . The total duration $2T$ of this jump control signal will for example be 400 μ secs. If it is assumed that at the beginning of this jump control signal ($t=0$) the mirror 8 is in the rest position, the speed of rotation of the mirror will exhibit a variation as indicated by V in Fig. 3b, i.e. initially an increasing speed until the instant $t=T$, after which the speed decreases again until at the instant $t=2T$ the speed is zero again. Fig. 3c shows the variation of the displacement S of the scanning spot corresponding to said variation of the speed of rotation of the mirror 8. For a correct choice of the amplitude K and the period $2T$ of the jump control signal K , the path-length S covered at the instant $2T$ will exactly equal the nominal track pitch P . This means that if the jump starts at the instant $t=0$ from the track Q_1 , the scanning spot A just coincides with the track Q_2 at the instant $t=2T$. The variation of the measuring signal I which occurs during this displacement of the scanning spot A is shown in Fig. 3d (owing to the variable speed V this variation deviates from the variation shown in Fig. 2b).

It will be evident that in this manner a correct jump of the scanning spot is only obtained if the actual track pitch equals the nominal value P , for which the variation of the jump control signal K has been designed. This track pitch, however, is subject to tolerances and so are of course the properties of the mirror drive 10 and the mirror 8. The effect of these tolerances on the displacement of the scanning spot may

simply be represented by a choice of the amplitude of the jump control signal K which deviates from the nominal value K_a . For illustration a jump control signal K having too low an amplitude is represented by the dotted line in Fig. 3c. The corresponding speed V' and the displacement S' of the scanning spot are represented by dotted lines in Figs. 3b and 3c, whilst the measuring signal I' is shown by the dotted line in Fig. 3d. It can then be seen from Fig. 3c that at the instant $t=2T$ a positional error ΔS of the scanning spot relative to the track Q_2 remains. At said instant $t=2T$ it is then obvious that there is a measuring signal $I'=\Delta I$ which differs from zero.

Whether the control system (after the closure of the control loop) will be capable of pulling the scanning spot to the track Q_2 , depends on said this positional error ΔS and the properties, such as bandwidth, of the control system. However, if this positional error is comparatively large, it is not unlikely that the scanning spot will fail to be pulled into said track Q_2 and will overshoot to an adjacent track, so that an unpredictable behaviour is obtained, which may seriously impair the read-out of the record. It has been assumed hereinbefore that no direction-dependent errors occur. This type of error may be represented by introducing an inequality between the two half-periods of the jump control signal K . As a result of this, a final speed error ΔV would arise in addition to a final position error ΔS , so that there would be an increased risk of the scanning spot not being pulled in on the track Q_2 .

Therefore, if in the known apparatus a correct jump of the scanning spot is to be ensured, very stringent requirements have to be imposed both on the read apparatus with its tracking system and on the record, in particular with respect to the track pitch.

Fig. 4 shows a first embodiment of the switching device 23, employed in the read apparatus of Fig. 1, whilst the signals associated with said switching device are shown in Fig. 5. This switching device 23 first of all comprises a bistable multivibrator 31 with a set input 31a and reset input 31b. The set input 31a is connected to the command device 24. When this set input 31a receives a jump start signal from the command device 24 at the instant $t=0$, the output signal of this multivibrator 31 assumes a positive value K_a (Fig. 5a). This output signal of the multivibrator is then maintained until a reset signal is applied to the reset input 31b. This reset input 31b is connected to a detection circuit 33 which is adapted to detect the instant at which the scanning spot is exactly halfway between two adjacent tracks on the record. For this

purpose this detection circuit 33 comprises two inputs, of which the first (input 33a) is connected to the detector 14 and consequently receives the measuring signal I supplied by the measuring detector 14. The second input 33b of this detection circuit 33 receives a reference signal, in the present instance earth potential.

If it is assumed that the positive signal supplied by the multivibrator 31 is applied to the drive means 10 of the mirror 8, the scanning spot will experience an accelerated movement in the direction of an adjacent track, which results in a variation of the measuring signal I as shown in Fig. 5b. As soon as this measuring signal I becomes equal to zero at the instant $t=T$, this measuring signal, which is applied to the input 33a, will equal the reference signal applied to the input 33b and this detection circuit 33, which takes the form of a comparator will produce a pulse-shaped output signal. This output signal is applied to the reset input 31b of the multivibrator 31, so that the output signal of this multivibrator 31 becomes zero again at this instant $t=T$.

This output signal of the detection circuit 33 is also applied to the set input 32a of a second bistable multivibrator 32. It is assumed that this multivibrator 32 supplies a negative output signal of the value K_2 (Fig. 5d) upon the appearance of a set signal at its set input 32a. The reset input 32b of this multivibrator 32 receives a signal from an amplifier 35 which in its turn is driven by a triangular wave generator 34. This generator 34 and the amplifier 35 serve to define an instant $t=2T$, reckoned from the instant $t=0$. For this purpose, the output signal of the multivibrator 31 is applied to the triangular-wave generator 34. In the time interval from $t=0$ till $t=T$, during which this output signal of the multivibrator 31 is positive the generator 34 supplies a linearly increasing signal (Fig. 5c, 34). After the instant $t=T$, at which the output signal of the multivibrator 31 returns to zero, the triangular-wave generator supplies a signal which decreases linearly from the value assumed at this instant $t=T$, the slopes of the rising and falling periods of this output signal being equal. This means that this output signal of the triangular-wave generator becomes zero again at the instant $t=2T$. By means of the amplifier 35 this triangular signal from the triangular-wave generator 34 is shaped into a square-wave signal (Fig. 5c, 35) which is applied to the reset input 32b of the multivibrator 32. This multivibrator 32 is reset by the negative-going edge of this output signal of the amplifier 35, i.e. at the instant $t=2T$.

In an adder circuit 36 the output signals of the two multivibrators 31 and 32 are added

to each other, which results in a control signal (Fig. 5e) for the drive means 10 of the mirror 8, which signal is suitable for performing the desired track-jumping displacement of the scanning spot. As previously stated, this jump control signal may be superimposed on the tracking control signal which is applied to said drive means 10, i.e. without interruption of the control loop. Preferably, the control loop is interrupted during the jump of the scanning spot. This again may be effected with the aid of the switch 16, the input 17 of this switch being again directly connected to the amplifier 15 and the input 18 being connected to the adder circuit 36. The amplifier 35 supplies a suitable control signal for the actuation of the switch 16 which in Fig. 4 is represented by a dotted line.

Figs. 5f and 5g, in a similar way to Figs. 3b and 3c, show the variation of the speed V and the displacement S of the scanning spot. In order to illustrate the effect of this embodiment of the invention, the variations of the various signals are represented in Fig. 5 by dotted lines for the case in which the amplitude of the output signals supplied by the multivibrators 31 and 32 is smaller than the nominal value K_2 . As previously stated in the description with reference to Fig. 3, this is equivalent to the assumption that the track pitch deviates from the nominal value.

As the jump control signal which is applied to the drive means 10 of the mirror 8 after the instant $t=0$ has a smaller value, the speed V' (Fig. 5f) will always be smaller than the nominal value V . As a result of this, the variation of the measuring signal I' which is supplied by the amplifier 15 will also deviate from the nominal variation I . The instant at which said measuring signal I' intersects the zero line will then have shifted towards a greater time value, say $t=T+\Delta T$. This means that the period of the positive pulse supplied by the multivibrator 31 also increases from T to $T+\Delta T$. With the aid of the triangular-wave generator 34 it is ensured that the period of the negative pulse supplied by the multivibrator 32 is also adjusted automatically to said change duration of the positive pulse, so that the control signal supplied by the adder circuit 36 remains symmetrical. From Figure 5 it can then be seen that the total duration of the jump has increased from $2T$ to $2T+2\Delta T$. This automatic adjustment of the duration of the control signal ensures that the displacement S at the final instant $t=2T+2\Delta T$ of this control signal again equals the nominal value λ . This is an unambiguous indication that a correct track-jumping displacement of the scanning spot is effected by the switching device according to Fig. 4

irrespective of tolerances in the track pitch and the amplitude of the control signal.

It will be evident that with respect to the specific switching device of Fig. 4 many modifications are possible. In a very simple embodiment the triangular wave generator 34 may comprise a capacitor and a current source switched by the multivibrator 31, which source during the first signal period of the switching signal charges said capacitor with a constant current and during the second signal period discharges it with the same current. The detection circuit 33 may simply comprise a comparator circuit which supplies one of two discrete output signals depending on which of the two input signals is greater.

Instead of the triangular-wave generator 34 it is obvious that it is alternatively possible to employ a counting circuit to determine the duration of the first signal period and thus to define the duration of the second signal period. The count of said counter can then be made to decrease during said second signal period and the multivibrator 32 may be reset upon said counter reaching the zero position. However, it is obvious that the output signal of this multivibrator 32 may alternatively be applied to a second counter, the multivibrator 32 being reset upon equality of the two counters. It is also possible to employ for example a bucket brigade device or a charge coupled device. During the first signal period a pulse count controlled by the multivibrator 31 may be read in, and subsequently the direction of the information shift may be reversed by the clock signal and the same pulse count be read out again.

A very simple example of the switching device 23 is shown in Fig. 6 and some associated signal waveforms in Fig. 7, corresponding elements being denoted by the same reference numerals as in Fig. 4. The embodiment of Fig. 6 again comprises the bistable multivibrator 31, whose set input 31a is connected to the command device 24 and whose reset input 31b is connected to the detection circuit 33. This multivibrator 31, however, now always supplies one of two signal values with an amplitude K , which are symmetrically disposed relative to the zero level (Fig. 7a). The output signal of this multivibrator 31 is again applied to a triangular-wave generator 34 and an amplifier 35, which results in the squarewave signal of Fig. 7b which corresponds to Fig. 5c. This squarewave signal controls the switch 16. In the embodiment shown this switch 16 takes the form of an electronic switch and first of all comprises a field-effect transistor 37. This field-effect transistor 37 is driven by the amplifier 35 and consequently conducts

only during the time-interval $t=0$ to $t=2T$. The main current path of this field-effect transistor 37 constitutes the connection between the output of the multivibrator 31 and the drive means 10, so that the correct jump control signal (Fig. 7c) for this drive means is obtained. Preferably, the tracking control loop can be interrupted at the same time during said jump control signal by the insertion of a field-effect transistor 38 in the connection between the amplifier 15 and drive means 10. If said transistor 38 is of a conductivity type opposite to that of transistor 37, the control signal for said transistor may also be taken directly from the amplifier 35.

In order to ensure correct operation of apparatus in accordance with this embodiment of the invention under all circumstances, a number of additional steps may be taken. Two of these steps are shown in Fig. 8. As can be seen from Fig. 5b the measuring signal I still has a very small value at the beginning of the track-jumping displacement, and may well be zero. This would result in an erroneous detection by the detection circuit 33 and this would give an erroneous control signal. In order to prevent this, a switch 43 is included in the connection between the detection circuit 33 and the reset input 31b of the multivibrator 31. This switch 43 is, for example, controlled by a monostable multivibrator 41 which receives the start signal from the command device 24. This arrangement ensures that the switch 43 is not closed until a specific time after the start signal from the command device 24, so that in fact the detection circuit 33 does not become operative until a specific time after said start signal, at which instant the measuring signal I has already assumed a sufficient value to avoid erroneous detection as a result of spurious signals.

A second additional step relates to the reference signal which is applied to the second input 33b of the detection circuit 33 which takes the form of a comparator. The measuring signal I supplied by the detector 14 will generally not be zero at the instant when the start signal is supplied by the command device 24. This detector 14 forms part of a control loop with which the radial position of the scanning spot is controlled, for which purpose the detector will always supply a certain error signal. If the speed with which the record carrier rotates is 1500 revolutions/minute, this measuring signal I will contain a 25 Hz component in the case of eccentricity of the record. This means that, for exact detection of the instant at which the scanning spot is half way between the two tracks, the measuring signal I should not be compared with earth potential, but with a reference signal in which said 25 Hz

component is contained. For this purpose, a lowpass filter 42 may be employed, which has a cut-off frequency higher than 25 Hz, but much lower than the frequency of the control signal. *Via* this low-pass filter a reference signal derived from the measuring signal I is then applied to the second input 33b of the detection circuit 33. An alternative is to supply the measuring signal to the first input 33a *via* a frequency-dependent amplifier, said 25 Hz component being highly attenuated. In that case the input 33b may again be at earth potential.

Two further additional steps to ensure correct track-jumping displacements of the scanning spot are schematically represented in Fig. 9. This Figure first of all shows that the command device 24 also influences the control amplifier 15. It is desirable for the control loop to have a large bandwidth during the jump of the scanning spot and preferably also a brief time after that, thus facilitating locking on to the new track. However, during normal tracking, a limited bandwidth is preferred in order to prevent unstable control behaviour so that *inter alia* the initial speed at the starting instant of the jump remains within certain limits. With the aid of the start signal from the command device the bandwidth of the amplifier 15 may then simply be extended during a desired period of time.

Secondly, the connection between the switching transistor 37 and the drive means 10 includes a capacitor C which is also connected to earth potential *via* a resistor R. During normal tracking the voltage across this capacitor C will follow the control signal applied to the drive means 10 *via* the transistor 38. At any given instant when a jump of the scanning spot is desired, the jump control signal which is applied to this capacitor C *via* the switching transistor 37 will be superimposed on the instantaneous voltage across the capacitor C. This means that, during the jump of the scanning spot, the tracking control signal appearing at the instant of the start signal remains operative.

Finally, it is to be noted with respect to the switching device used in the apparatus that many modifications are possible. Comparator circuits, multivibrators, triangular-wave generators and the like are known in many forms, and may be employed in this switching device. Also with respect to the optical read system which is used it is obvious that this is not limited to the embodiment which is schematically shown in Fig. 1.

WHAT WE CLAIM IS:—

1. Apparatus for reading a disk-shaped record on which information is recorded in optically coded form in tangentially

extending tracks, as defined hereinbefore which apparatus comprises a radiation source for producing a read beam of radiation, a tracking system for ensuring that a scanning spot produced by said read beam on the record follows a desired track, a read detector for converting the information contained in said read beam after cooperation with the record into an electrical signal, a measuring detector for supplying a tracking measuring signal giving the radial position of the scanning spot relative to the desired track and supplying a corresponding tracking control signal to the tracking system, and a switching device for causing the scanning spot to jump from any given scanned track to an adjacent track in response to a start signal which is supplied by a command device, which switching device comprises a signal source for supplying to the tracking system a jump control signal suitable for causing such a jump which jump control signal comprises two consecutive signal periods of substantially the same duration and substantially the same shape, but of opposite polarity, characterized in that the switching device includes a detection circuit for detecting the instant at which the scanning spot is located half-way between the two adjacent tracks during a jump and for supplying at that instant a detection signal to the signal source, and in that said signal source is adapted to supply the jump control signal as a signal whose two signal periods each have a duration which automatically substantially equals the time interval between the start signal and the detection signal.

2. Apparatus as claimed in Claim 1, characterized in that the detection circuit includes a comparator with a first input, to which is applied the tracking measuring signal and a second input to which a reference signal is applied, which comparator supplies the detection signal in response to equality of the two signals at its two inputs.

3. Apparatus as claimed in Claim 2, characterized in that the reference signal is supplied by a low-pass filter with a cut-off frequency higher than the frequency which corresponds to the speed of the record, to which filter the tracking measuring signal is applied.

4. Apparatus as claimed in Claim 2 or Claim 3, characterized in that the detection circuit comprises time delay means for rendering said detection circuit operative only after a predetermined time interval after the start signal.

5. Apparatus as claimed in any of the preceding Claims, characterized in that the signal source includes a first bistable multivibrator with a set input which is

component is contained. For this purpose, a lowpass filter 42 may be employed, which has a cut-off frequency higher than 25 Hz, but much lower than the frequency of the control signal. *Via* this low-pass filter a reference signal derived from the measuring signal 1 is then applied to the second input 33b of the detection circuit 33. An alternative is to supply the measuring signal to the first input 33a *via* a frequency-dependent amplifier, said 25 Hz component being highly attenuated. In that case the input 33b may again be at earth potential.

Two further additional steps to ensure correct track-jumping displacements of the scanning spot are schematically represented in Fig. 9. This Figure first of all shows that the command device 24 also influences the control amplifier 15. It is desirable for the control loop to have a large bandwidth during the jump of the scanning spot and preferably also a brief time after that, thus facilitating locking on to the new track. However, during normal tracking, a limited bandwidth is preferred in order to prevent unstable control behaviour so that *inter alia* the initial speed at the starting instant of the jump remains within certain limits. With the aid of the start signal from the command device the bandwidth of the amplifier 15 may then simply be extended during a desired period of time.

Secondly, the connection between the switching transistor 37 and the drive means 10 includes a capacitor C which is also connected to earth potential *via* a resistor R. During normal tracking the voltage across this capacitor C will follow the control signal applied to the drive means 10 *via* the transistor 38. At any given instant when a jump of the scanning spot is desired, the jump control signal which is applied to this capacitor C *via* the switching transistor 37 will be superimposed on the instantaneous voltage across the capacitor C. This means that, during the jump of the scanning spot, the tracking control signal appearing at the instant of the start signal remains operative.

Finally, it is to be noted with respect to the switching device used in the apparatus that many modifications are possible. Comparator circuits, multivibrators, triangular-wave generators and the like are known in many forms, and may be employed in this switching device. Also with respect to the optical read system which is used it is obvious that this is not limited to the embodiment which is schematically shown in Fig. 1.

WHAT WE CLAIM IS:—

1. Apparatus for reading a disk-shaped record on which information is recorded in optically coded form in tangentially

extending tracks, as defined hereinbefore which apparatus comprises a radiation source for producing a read beam of radiation, a tracking system for ensuring that a scanning spot produced by said read beam on the record follows a desired track, a read detector for converting the information contained in said read beam after cooperation with the record into an electrical signal, a measuring detector for supplying a tracking measuring signal giving the radial position of the scanning spot relative to the desired track and supplying a corresponding tracking control signal to the tracking system, and a switching device for causing the scanning spot to jump from any given scanned track to an adjacent track in response to a start signal which is supplied by a command device, which switching device comprises a signal source for supplying to the tracking system a jump control signal suitable for causing such a jump which jump control signal comprises two consecutive signal periods of substantially the same duration and substantially the same shape, but of opposite polarity, characterized in that the switching device includes a detection circuit for detecting the instant at which the scanning spot is located half-way between the two adjacent tracks during a jump and for supplying at that instant a detection signal to the signal source, and in that said signal source is adapted to supply the jump control signal as a signal whose two signal periods each have a duration which automatically substantially equals the time interval between the start signal and the detection signal.

2. Apparatus as claimed in Claim 1, characterized in that the detection circuit includes a comparator with a first input, to which is applied the tracking measuring signal and a second input to which a reference signal is applied, which comparator supplies the detection signal in response to equality of the two signals at its two inputs.

3. Apparatus as claimed in Claim 2, characterized in that the reference signal is supplied by a low-pass filter with a cut-off frequency higher than the frequency which corresponds to the speed of the record, to which filter the tracking measuring signal is applied.

4. Apparatus as claimed in Claim 2 or Claim 3, characterized in that the detection circuit comprises time delay means for rendering said detection circuit operative only after a predetermined time interval after the start signal.

5. Apparatus as claimed in any of the preceding Claims, characterized in that the signal source includes a first bistable multivibrator with a set input which is



coupled to the command device and a reset input which is coupled to the detection circuit, a second bistable multivibrator with a set input which is coupled to the detection circuit and a reset input, a measuring circuit for determining the duration of a pulse supplied by the first multivibrator and for supplying a reset signal to the reset input of the second multivibrator which reset signal is delayed by said measured time interval relative to the end of said pulse from the first multivibrator, and an adder circuit for adding the pulses supplied by the first and second multivibrators to each other with opposite polarity so as to obtain the jump control signal.

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bistable multivibrator for supplying, during a pulse from said multivibrator, a signal which increases substantially linearly from a limit value and subsequently decreases with the same slope, a pulse shaper for shaping said signal from the signal generator into a pulse whose edges correspond to the instants at which said signal from the signal generator equals the limit value, and a switch which is included in the connection between the multivibrator and the tracking system and which is controlled by the pulse from the pulse shaper.

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7. Apparatus substantially as described with reference to Figures 4 to 9 of the accompanying drawings.

6. Apparatus as claimed in any of Claims 1 to 4, characterized in that the signal source comprises a bistable multivibrator with a set input which is coupled to the command device and a reset input which is coupled to the detection circuit, a signal generator which is controlled by said

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