

This invention relates to a process for regenerating the phase of synchronisation signals used in an apparatus for optical transcription of data on an information medium, during the writing and/or reading phases, particularly of numerical data recorded on a disc. It also concerns an optical device for implementing this process.

The methods of recording are well known to the specialist and fall outside the scope of this invention; this information is generally recorded in the form of microreliefs along a track having the configuration of a spiral or of concentric circles, the latter configuration being used most when it is a question of recording numerical data. In particular it facilitates random access to an item of recorded data and also a recording divided into blocks or sectors.

During read-out, whatever the method of recording, it is necessary to have signals providing for the synchronisation of this read-out. To do this, many methods are equally known.

According to a first method, in the systems termed multi-track, with each track reserved for the recording of useful information, is associated at least one other track along which are recorded various items of information and in particular clock signals permitting synchronisation of the reading of the useful information. In a constructional variant, the tracks intended for the synchronisation are pre-engraved and comprise optically discernible regularly spaced disturbances. During the reading, in a first variant (multibeam system), a first beam is focused onto the useful information track and used to read these data, and a second beam, separate but in a relationship of constant mechanical coupling with the first, is used to read the synchronisation data. In a second variant, (single beam system) a single beam reads both types of information. In this case, it is necessary for the two types of information to be easily distinguishable. By way of example, the frequency spectra associated with these types of information may be different. In this variant the pre-engraved synchronisation information can also be used during

the writing phase. From the document GB-A-2,069,214 an information medium is known corresponding to the second variant mentioned above, the reading of which however makes use of the exploration of the track with two beams the points of impact of which are set back in relation to each other. Provision is made for the retiming in phase of a clock signal read by the first beam with a portion of the signal read by the second beam.

To increase the possible density of recording, it was also proposed to use a single track. In this case, the clock signals for synchronisation can be derived from the reading of the information itself. To make the synchronisation easier, it is conventional to use codes termed self-synchronising or maximum transitions codes, whatever the content of the source information to be recorded. In fact, practically, the microreliefs have two reference levels, associated with the logic values "0" and "1" respectively. The synchronisation signals are derived from the detection of the transition from one set level to the other. However this type of coding does not allow a maximum recording density. To increase this density, the use is also known of non-self-synchronising codes for example the N.R.Z. (non-return to zero) code. This type of code has the characteristic of not showing any transition from one bit of information to the other if these two bits remain at the same logic value. It is then more difficult to derive the signals necessary for the synchronisation from the reading of the information thus encoded. A solution to this problem may be found by arranging along the tracks, regularly or not, recorded elements used solely for the synchronisation, or flags. Naturally these flags must be "transparent" to the electronic circuits the function of which is to detect and to process the useful information. These synchronisation samples serve whenever a flag passes under a reading head to synchronise circuits for generating synchronisation signals. It is therefore extremely important for the re-synchronisation moments to be defined with great accuracy, because the latter are fewer than in the processes mentioned above.

Now many phenomena may cause a deterioration in the quality of the synchronisation. For example errors may be cited in focusing

of the reading beam and also errors in radial following of the track which show themselves, respectively, through variations in the area of the reading spot or an offset of this spot with respect to the average centreline of the tracks to be followed. This results in variations in the shape of the signals detected, particularly variations of the rising and descending fronts of these signals. Now, to derive a synchronisation signal from the signals read, as has been mentioned, it is conventional in the known art to use one of these fronts. One may, for example, utilise a logic element having a threshold detecting the coincidence of the amplitude of the signal read with this threshold. The variations in the moment when this detection occurs due to the parasitic phenomena mentioned then show themselves through an incorrect synchronisation of the reading or of the writing of the data.

This invention has the purpose of alleviating the deficiencies of the known art, particularly of greatly reducing the effect of the errors in focusing and in radial track following on the synchronisation of the reading or of the writing.

The object of the invention is therefore a process for generating synchronisation signals (H_s) in an optical apparatus for recording-reading numerical information data on a medium (90) driven with a uniform movement; the said data being recorded in the form of disturbances (92) of at least one layer of material of the medium optically detectable along tracks (91) of set configuration; the said apparatus comprising means for focusing in an exploration spot (t_a) a beam (f) of light energy onto one of the said tracks and optoelectronic means (1) for detecting the interaction of this beam with the said disturbances running under the exploration spot; process characterised in that it comprises;

- a preliminary phase consisting of the writing of specific numerical data (92) in the form of a succession of disturbances of the said layer of material at given sites of the said tracks selectively identifiable by the optoelectronic means of detection (1, 2);

- and a phase of regeneration of the said synchronisation signals comprising the following stages:

- . generation external to the medium of a periodic clock signal at fixed frequency (H);

- . selective identification of the specific numerical data by the optoelectronic means of detection;

- . determination of the moment (T_C) of intersection of the centre of one of the said disturbances composing the specific numerical data with a line passing through the centre (O) of the exploration spot and at right angles to the average direction of the track explored (91);

- . determination of the amplitude and of the sign of the displacement of this moment in comparison with a reference moment of the period of the clock signal (H);

- . and generation of a synchronisation signal (H_S) of the same frequency as the clock signal and having a phase displacement directly proportional in amplitude and sign to the said displacements.

A further object of the invention is a device for implementing such a procedure and the information medium particularly adapted to this process.

The invention will be better understood with the help of the following description referring to the attached figures among which:

- figures 1 and 2 illustrate two types of characteristic situations arising during the reading of information, namely focusing errors and radial following errors;

- figure 3 illustrates two types of codes utilised for the encoding of the same binary word;

- figure 4 is a diagram illustrating a particular code utilised in a preferred variant of the invention;

- figure 5 is a general diagram of a device according to the invention;

- figures 6 and 7 show in greater detail certain elements of these devices;

- figure 8 is a diagram in which are shown the more significant signals of the operation of the device according to the invention and their temporal interrelations.

The processes for writing information onto an optical disc are well known. Usually the disc comprises at least one layer, generally superficial, of material sensitive to certain types of radiation. According to one of the best known processes, during the writing, a beam generated by a laser source is focused onto this layer of material and by thermo-optical effect microreliefs are created along the tracks. These tracks may be virtual, i.e. may be created at the moment of the writing of the data, or else may be pre-engraved in whatever form it may be. The processes of reading the information and of track following are also well known. For the track following, use is generally made either of a second reading beam, or of the beam which was used for the writing or else the same beam serves for all of the functions. The interaction of this beam with the microreliefs running under a reading head creates orders of interference which are detected by opto-electronic means of detection. The reading may be performed either by transmission through the detection disc by means of photodetector cells placed close to the lower face of the disc, or by reflection of the radiation onto the disc and backward return of the light picked up by optical systems comprising mirrors directing the reflected beams towards photodetector cells.

As well as radial following, the photodetector cells may also be used to ensure correct focusing of the reading beam onto the recorded face. Lastly, these cells are used to generate electrical signals representing the recorded information.

For applications in the data processing field, it is necessary to be able to record data of numerical type in a random manner at any place whatever of the disc. Similarly during reading, random access to these data is also required. Another requirement raised by this type of device is that the reading has to be synchronised on the writing. Now, for many reasons due to parasitic phenomena such as fluctuations of speed, an external clock is inadequate.

quate for this purpose. The synchronisation signals must therefore be derived directly from the recorded data so as to have a correlation between the data read and the data written.

Practically, the micro-reliefs which appear in the form of deformations along tracks associated with two well-defined levels and separated by transitions between these two levels. The inter-track zones are uniform zones having one of these levels depending on whether the micro-reliefs are recessed or in relief. The means of detection will translate these variations in level as a succession of pulses also having two states which can be associated with logic states "0" and "1" and also having more or less abrupt transitions between these two states.

In the known art, it is customary to derive synchronisation signals from the appearance of one of these transitions, for example a rising front or a descending front. A correct synchronisation assumes that the moment of appearance of these rising or descending fronts can be defined with sufficient accuracy and does not fluctuate in time. Now, due to focusing errors and radial track following errors, this condition is not met in practice.

Figure 1 illustrates the effect of focusing errors. This figure diagrammatically illustrates a micro-relief m representing an elementary item of numerical data recorded along a track 91 having an average centreline 910. In general the micro-relief shows a symmetry with respect to this centreline. The same figure shows the impact of the reading spot t_a when the beam is correctly focused. It has been assumed, as is generally the case, that the spot shows a symmetry of rotation of centre O , this point O being merged at the moment shown in the figure with the centre of symmetry of the micro-relief m . It must be understood that the spot and the micro-relief are driven with a relative movement because of the rotation of the disc. In the lower part of the figure, the curve W represents the convolution of the spot t_a with the micro-relief. This curve is homothetic to the distribution of the energy diffracted by the spot in terms of the distance to the point O , and also to the curve of the energy picked up by a pin-point detector in terms of time when the

micro-relief carried along by the rotation of the disc runs under the reading spot.

When focusing is poor, the reading spot acquires a larger area. This case is illustrated by the outline referenced t'_a . The corresponding convolution curve is w' . The envelope of this curve is much wider than the envelope of the curve w .

Figure 2 for its part illustrates the effect of the radial following error. Again, two spots are shown; t_a , correctly centred under the average centreline of the track 81, and a spot t''_a off-centre with respect to this average centreline. The corresponding convolution curves are respectively w and w'' . We find again that the envelope of the curve w'' is wider and of lesser amplitude than that of the curve w .

However the curves w , w' and w'' have an interesting characteristic, namely that all of these curves have the same axis of symmetry. The same applies to the electrical signals supplied by the means of detection in response to the interaction of the reading spots with the running of the micro-reliefs. The moment when the centre of each micro-relief passes under the reading spot and the centre of the reading pulse generated by the means of photodetection remain merged, provided that the spot and the micro-relief have a symmetry of rotation at least along one axis. The spot may be of ellipsoidal shape, for example, as is the case when a semi-conductor laser is used.

The invention takes advantage of this property and proposes a process permitting a synchronisation which does not vary with the form factor. According to the main characteristic of the invention, the pulses necessary to define a synchronisation during the reading or the writing of numerical information are generated in synchronism with the passing of the centre of symmetry of micro-reliefs under a reading head; these micro-reliefs may be specific, i.e. recorded for the sole ends of generating synchronisation pulses or else may be constituted by the numerical data recorded.

As has been mentioned, the numerical information can be recorded in a manner encoded according to diverse rules. A first series of codes are termed self-synchronising or at least offer the maximum of transitions. To increase the recording density, it is customary to use other types of codes such as for example the code termed N.R.Z. (non-return to zero).

Figure 3 illustrates both types of code: the pulse code and the N.R.Z. code, this for an arbitrary binary word having the following logic states: 0 1 0 0 1 1 1 0 1 1 0. Upon seeing figure 3 one realises immediately that the pulse code offers much more transition than the N.R.Z. type. It will then be more difficult to derive information for the synchronisation from the latter. In the figure, the period T represents the duration of an elementary binary signal or bit which corresponds to a frequency of rate $f = 1/T$.

Although the invention is not limited to this sole variant, in the case where a code of the N.R.Z. type or similar is used, specific recordings or flags used for the sole ends of generating synchronisation signals will preferably be utilised. These flags may be written prior to any writing of useful information and are then used for the generation of synchronisation signals during the writing of these data and during the successive readings; or else are multiplexed in time with the writing of these data and are used during the subsequent reading of the latter.

In these two cases, it is necessary for these specific data to be selectively identifiable by the means of reading so as to generate synchronisation signals solely correlated to the appearance of these specific flags and conversely "transparent" during the reading of the useful information.

To do this, if a code of the N.R.Z. type is used, specific flags are recorded in the form of pulses the time intervals of which between fronts of the same nature are prohibited in the modulation code. For the N.R.Z. code the durations T and whole multiples of T are used. For the specific pulses recorded a duration is chosen equal to the shortest, half-whole duration usable i.e. $1.5 T$.

Such a pulse is illustrated by the diagram of figure 4. A first part is at the logic "1" during the interval of time equal to $1.5 T$ and at the logic "0" during the time interval equal to T . The process of the invention according to a preferred variant will now be described in greater detail with the help of the device shown in the general diagram of figure 5. The optoelectronic detection devices and the associated electronic circuits 1 supply a reading signal V_L transmitted on the one hand to conventional circuits for processing the information read 6 and, on the other hand, to the specific circuits of this invention.

According to the process of the invention, it is first of all necessary to determine whether the signals V_L have come from the reading of useful information or on the contrary from the reading of flags intended for the synchronisation. This stage is performed by means of flag detection circuits 2 details of which will be given later. These circuits supply an authorisation signal V_A transmitted to phase displacement calculation signals 3. These circuits, according to the fundamental characteristic of the invention, have the purpose of supplying information C representative of the moment when there is a coincidence between the centres of the optical spot and of the micro-relief running under this spot. The authorisation signal V_A , for example after logic reversal $\bar{V}_A$ by the inverter 7, can be used for purposes of inhibiting-authorising operation of the circuits for processing of the information read 6.

The device also comprises clock circuits 4 generating synchronisation pulses H regenerated by circuits 5, i.e. put back into phase and transmitted in the form of a re-synchronised signal H_S to the circuits for processing of the information read. Clock circuits also supply the phase displacement calculation circuit 3 with the reference clock signals H_R and the signals H. In conventional manner, these clock circuits comprise a highly stable quartz-controlled oscillator.

Preferably, the identification of the flags and also the generation of the information necessary for determining the coincidence between the passing of the centre of each micro-relief and the

optical centre of the reading spot can be performed by means of a single circuit which performs the double detection of the rising and descending fronts of two successive pulses composing a flag.

Such a circuit is illustrated by figure 6. This circuit comprises a first circuit 20 for normalisation of the signal read V_L . It may advantageously be constituted by a bistable element comparing a read signal V_L with a threshold voltage $V_{THRESHOLD}$ supplying a pulse V_{LS} , for example at a logic state "1" when the signal read exceeds the threshold and at the state "0" in the opposite case. This signal V_{LS} is transmitted to two circuits 21 and 22 adapted to generate two pulse-type signals defining time windows.

These signals are illustrated by the diagram of figure 8. The curve H represents pulses supplied by the clock 4 of basic duration T. The pulse-type signal V_{LS} may show a phase-displacement with respect to the clock signals whatever modulo the period of these signals. Owing to the property of invariance mentioned above, the period of time between two fronts of the same nature, rising or descending, is also invariant at the first order with the form factor. It is therefore equal to $2.5 T$.

The first circuit, 21, is triggered by the rising front of the first flag pulse, at the moment T_1 in the diagram, and delivers a pulse V_{FA} in of which the centre is delayed by $2.5 T$. The second circuit, 22, is triggered by the first descending front, at the moment T_2 , and also delivers a pulse defining a time window V_{FB} offset by the same value. The circuits of figure 6 also comprise two "AND" gates 23 and 24 receiving on a first input the signals V_{FA} and V_{FB} respectively and on a second input respectively the signal V_{LS} and this same signal reversed by the logic inverter 25. On the outputs of the "AND" logic circuits 23 and 24 the signals V_{SA} and V_{SB} are available the respective rising fronts of which coincide with the rising front and the descending front of the second flag pulse, i.e. with the moments T_A and T_B . In correctly setting the durations of the time windows V_{FA} and V_{FB} at the state "1", the "AND" gates 23 and 24 deliver pulses only when there is reading of a code associated with the flag. In the opposite case,

these outputs will remain at the logic state "0". The first function, of identification of the flags, is therefore performed.

From the information concerning the times T_A and T_B it is possible to determine the average of these two times, T_C , representing the centre of the second flag pulse. The authorisation signal of the type of that illustrated in figure 5: V_A , can be derived from the signal V_{SB} .

The circuits 21 and 22 can be constructed starting from each of two monostables delivering pulses triggered respectively by the rising and descending fronts and of duration a little greater and a little less than the time interval $2.5 T$. The logic intersection of these two pulses may be used to determine the time window.

Figure 7 shows in greater detail the other circuits of the devices of figure 5. The pulse type signals V_{SA} and V_{SB} are transmitted to a digitising circuit 30 supplying binary words A and B representing the displacement of the rising fronts of these signals with respect to a reference moment. To do this, use is made of the clock signal H and a clock signal H_R of frequency which is a multiple of the repetition frequency of the basic clock signal H and having a fixed phase relationship with this signal. The second clock signal may easily be derived from the clock signal H by means of a frequency multiplier. By way of example, in the diagram of figure 8, the clock signal H_R has a repetition frequency sixteen times higher than that of the signal H. It therefore defines sixteen sub-intervals. A decoder circuit can supply two binary words A and B representing the displacement of the moments T_A and T_B with respect to a fixed reference moment of the period of the basic clock signal H, this modulo sixteen. An interpolation circuit 31 can associate with each A and B pair a binary word C representative of the offset of the centre T_C of the second flag pulse, with reference to the same reference moment of the period of the basic clock signal H. These interpolation circuits may advantageously be constructed using a memory of the programmable read only (P.R.O.M.) type.

This item of information serves to put back in phase, whenever a flag passes, the clock signal used as synchronisation

signal H_S . This signal can serve, either during the reading of numerical data between the passing of two flags, or, when these flags are written prior to the recording of data in the form of pre-engravings, also for the writing of these data.

The new clock signals regenerated must be in constant phase relationship with the passing under the reading spot of the centre of the micro-relief m , i.e. with the moment T_C , centre of the second pulse of the flag as it has just been determined. The synchronisation signals H_S have the same frequency as the clock signals H and a phase relationship depending on the value of the command word C . This command word C is memorised during the time interval elapsing between the passing of two successive flags.

After calculation of a new command value C , it is necessary, in most applications, for the putting of the synchronisation signals H_S back into phase not to be performed in a random manner. In a preferred variant embodiment of the invention, a new synchronisation signal is generated showing with the clock signal H a phase displacement determined by the new value of C calculated. This new signal is substituted for the old as synchronisation signal at a well-determined moment. This may be for example, the appearance of the first descending front of the new clock signals. To do this, as a non-exhaustive example, use may be made of two distinct circuits for generating synchronisation clock signals, the respective outputs H_{S1} and H_{S2} of which are used alternately after each flag detection as synchronisation signals H_S . Each of these circuits, 51 and 52, may comprise for example a programmable delay line or an oscillator having a phase locking retro-action loop controlled by the binary word C . They each further comprise a register, 510 and 520, adapted to record this command word C . A two-position switch 50 directs this command word alternately towards these registers at the rate of the passing of the flags and of the calculations of the values C . At each detection of the flags, for example on the rising front of the signal V_{SB} , a circuit 53, of the bi-stable type, supplies a command signal V_{C1} to the switch 50. This signal is also transmitted to a

second switch 55 receiving on two inputs the clock signals H_{S1} and H_{S2} transmitted alternately to a clock selector 56. This selector circuit receives on one input the command signal V_{C1} and transmits this signal to a third switch 54 in the form of a command signal V_{C2} during the detection of the first descending front of the clock H_{S1} or H_{S2} which is sent to it by the switch 55 and which follows the transition of the command signal V_{C1} . This selector may be made using a JK type flip-flop. The command signal V_{C2} controls the directing of the switch 54 and connects the outputs of the circuits 51 and 52 alternately to the link carrying the synchronisation signals H_S .

The lower part of the diagram of figure 8 illustrates the operation of the circuits which have just been described. At the moment T_B , if the time required for the interpolation is disregarded, a value of C is available on the output of the interpolation circuits 31. If we assume that the current synchronisation signals H_S are supplied by the output from the circuits 51: H_{S1} , at the moment T_4 , when the signal V_{SB} falls again, the new value of C is sent to the register 520 and the clock signals H_{S2} have put back into phase in accordance with this new value C . The substitution of the new clock signals H_{S2} for the former clock signals H_{S1} take place at the moment T_5 coinciding with the first descending front of these new clock pulses. The switch 54 then connects the link carrying the signals H_S to the output of the circuits 52. The clock signals H_{S2} will serve as synchronisation signals up to the next detection of the passing of a flag under the reading spot t_a and calculation of a new value of C according to the process which has just been described.

It must be understood that the switches 50, 54 and 55 are made from electronic circuits, for example "EXCLUSIVE OR" logic gates receiving on a first series of inputs the signals to be directed and on a second series of inputs the command signals V_{C1} or V_{C2} .

This invention may be implemented in many devices using optical means for writing-reading of information medium. It is compatible with the processes deriving the synchronisation signals from the information recorded or processes utilising specific flags,

these latter being recordable at predetermined sites of the tracks, regularly spaced or not. In a particular variant embodiment, as has been mentioned, these flags may be pre-engraved and may serve for the generation of synchronisation signals during the recording of subsequent numerical data. The process of the invention therefore allows a great flexibility of use.

In certain applications, radial track following is also performed using flags spread along the tracks. The same may also apply where focusing is concerned. In this case the process of the invention makes these techniques easier. In fact, as was mentioned with reference to figures 1 and 2, the process allows a broad tolerance as regards focusing errors and radial following errors. If we refer once again to figure 2, the zone of detectability of the flags defines an imaginary track 911 of the order of magnitude having twice the diameter of the reading spot t_a . If the zones of detectability of two contiguous tracks overlap one another, the synchronisation can be rendered completely independent of the radial track following. This can advantageously be used for the phases of jumping from one track to the other, it being possible for the two tracks not to be contiguous. This type of operation is performed for a random search for an item of information. During these track jumping phases, the synchronisation can therefore be maintained although there is no longer any radial track following. In fact, the disc continuing to turn, the reading spot will encounter flags intended for re-synchronisation, these flags belonging to different tracks during the intersection of the tracks by the path of the reading spot.

To give a clear idea, figure 9 illustrates diagrammatically an example of an apparatus for recording-reading on a medium by optical means in which the process of this invention can be utilised. A disc 90 turning in a plane X or Y about an axis parallel with the third axis of the reference trihedron comprises on its upper face a layer of heat-sensitive material in which data have been recorded along the tracks 91. These tracks also comprise flags 92 associated

with a specific code in accordance with what has been described. The disc, having a diameter of about 30 cm, is driven with a rotation movement communicated by a drive motor securely attached to the chassis of the optical recording-reading system. Typically, the tracks, 40,000 in number for example, are written inside a ring centred on the axis of rotation and of width equal to about 8 cm. The number of flags written per concentric circular track must be sufficient to overcome parasitic phenomena associated with the nature of the medium or with the fluctuation in the rotation speed. Typically, 3,500 flags per track are written, taking the above data into account.

In the constructional example illustrated by figure 9, the device for access to a predetermined track of the disc includes a fixed part comprising a power source (not shown) generating a beam of parallel rays f and a movable part constituted by the recording-reading head proper. As known, the latter comprises an objective of the microscope type O_p , rigidly attached to an electromagnetic coil B moving in the magnetic field of a permanent magnet (not shown) providing vertical control or focusing and a galvanometer mirror M_1 providing radial control. The galvanometer mirror M_1 is movable about an axis Δ_y parallel with the axis OY of the reference trihedron so as to provide the said radial control. The beam f is focused into a spot t_a at a set place of the disc on one of the above-mentioned tracks 91. It is assumed here that the system is of the single beam-single track type, i.e. a system in which the single beam f serves alternately for the writing and for the reading and also to perform the functions of radial track following and focusing. This aspect falls outside the scope of the invention.

To detect the reading beam reflected by the disc, a semi-transparent plate M_2 is interposed, for example, on the path of the single beam f . The beam reflected by the disc is then detected by photodetector means D which generate the signal V_L to circuits 93 for processing of this signal. These circuits comprise in particular circuits peculiar to the invention, for example the device described

with reference to figure 7.

The invention is also compatible with the recording-reading devices utilising more than one beam, for example a reading beam and a writing beam.

CLAIMS

1. Process of regeneration of synchronisation signals (H_s) in an optical apparatus for recording-reading of numerical information data on a medium (90) driven with a uniform movement; the said data being recorded in the form of disturbances (92) of at least one layer of material of the medium optically detectable along the tracks (91) of set configuration; the said apparatus comprising means for focusing into an exploration spot (t_a) a beam (f) of light energy onto one of the said tracks and optoelectronic means (1) for detecting the interaction of this beam with the said disturbances running under the exploration spot; process characterised in that it comprises;

- a preliminary phase consisting of the writing of specific numerical data (92) in the form of a succession of disturbances of the said layer of material at set sites of the said tracks selectively identifiable by the optoelectronic means of detection (1, 2);

- and a phase of regeneration of the said synchronisation signals comprising the following stages:

- . generation external to the medium of a fixed frequency periodic clock signal (H);

- . selective identification of specific numerical data by the optoelectronic means of detection;

- . determination of the moment (T_c) of intersection of the centre of one of the said disturbances composing the specific numerical data with an axis passing through the centre (O) of the exploration spot and at right angles to the average direction of the track explored (91);

- . determination of the amplitude and of the sign of the displacement of this moment in comparison with a reference moment of the period of the clock signal (H);

- . and generation of a synchronisation signal (H_s) of the same frequency as the clock signal and having a phase displacement directly proportional in amplitude and sign to the said displacements.



2. Process according to claim 1, characterised in that the numerical data to be recorded are binary pulses coded in accordance with the rules of the N.R.Z. code and in that, the said pulses having durations exclusively equal to a set elementary value T or to a whole multiple of this value, the specific numerical data are constituted by a succession of pulses (fig. 4) of a duration equal to one and a half times this value separated by time intervals equal to this value T so as to permit the said selective identification stage.

3. Process according to claim 2, characterised in that the stage of determining the moment of intersection is performed by detection of the moment of occurrence of successive transitions (T_A , T_B) of opposite directions of one of the pulses of the specific numerical data and calculation of the average (T_C) between these two moments.

4. Process according to claim 2, characterised in that the identification stage and the stage of determination of the moment of intersection are merged into a single stage and in that there is performed a double detection of the moment of occurrence of two successive transitions of a first direction and of two successive transitions of a second direction by generation of first (V_{FA}) and second (V_{FB}) time windows initialised by the first transitions of the first and second directions and delayed by a time interval equal to one and a half times the said set elementary value T , generation of two pulses (V_{SA} , V_{SB}) in synchronism with the second transitions of the first and second directions, the generation being conditioned to the coincidence of the occurrence of the transitions inside the said time windows and determination of the moment of intersection starting from the calculation of the average (T_C) of the moments (T_A , T_B) of occurrence of these two pulses.

5. Process according to any of claims 1 to 4, characterised in that the synchronisation signal (H_S) being of the pulse type, the synchronisation signal regeneration stage is performed by the generation of a new synchronisation signal (H_{S2}) at each new regeneration



phase showing a phase displacement directly proportional in amplitude and in sign to the new displacement determined during this phase and substitution for the synchronisation signal (H_{S1}) generated during the preceding phase in synchronism with the moment (T_4) of appearance of the next transition of set direction of the said pulses of the new synchronisation signal (H_{S2}).

6. Process according to any of claims 1 to 5, characterised in that the writing during the preliminary phase of the specific numerical data is performed prior to the writing of any numerical information data on the said medium and in that the said regenerated synchronisation signals (H_S) are used in subsequent phases, for synchronised writing and reading of these numerical information data.

7. Process according to any of claims 1 to 5, characterised in that the writing during the preliminary phase of the specific numerical data is multiplexed in time with the writing of the information numerical data and in that the said regenerated synchronisation signals (H_S) are used in subsequent phases for the synchronised reading of this information.

8. Process according to any of claims 1 to 7, characterised in that the said specific numerical data are written at sites (92) regularly spaced along tracks (91) defining between these sites blocks reserved for the writing of numerical information data.

9. Device for regeneration of synchronisation signals according to any of claims 1 to 8, comprising means (4), external to the synchronisation signals medium, for generation of a periodic reference signal and of clock signals from which are generated the said synchronisation signals, and at least optoelectronic means for reading of an information medium (90) on which are recorded along track (91) numerical information data composed of pulses (92) of duration equal to a set time interval T or whole multiple of this interval and also specific numerical data of duration equal to one and a half times the duration T separated by time intervals equal to this duration; characterised in that it comprises means (2) for selective detection of the said specific pulses, means for determining the phase displacement (3) of the middle of one of the pulses composing



the specific data by comparison with a reference moment of the period of the said clock signal (H) generating a command signal (C) representative of the sign and of the phase displacement amplitude and means for putting back into phase (5) the clock signals (H) so as to regenerate the said synchronisation signals (H_S).

10. Device according to claim 9 characterised in that the specific numerical data (fig. 4) comprising at least two pulses, the means (2) for selective detection of specific numerical data and the means (3) for determination of phase displacement comprise in common a double detector of the transitions of these pulses receiving the output signals (V_L) of the said optoelectronic means for reading and comprising a logic element (25) inverting the said signals, a first generator (21) of time window (V_{FA}) initialised by the first transition of a first direction of the said pulses composing the specific numerical data and delayed by a time interval equal to one and a half times the said set elementary duration T, a second generator (22) of time windows (V_{FB}) initialised by the first transition of reverse direction of the said pulses composing the specific numerical data and delayed by the same time interval, first (23) and second (24) "AND" logic gates receiving on a first series of inputs the output signals from the time window generators and a second series of inputs receiving respectively, for the first logic gate, the output signal from the optoelectronic means for reading and for the second logic gate, the inverted signal.

11. Device according to claim 10, characterised in that the means for determination of phase displacement (3) further comprise a first circuit (30) for digitising the output signals from the said logic gates into two representative binary words (A, B) and an interpolation circuit (31) generating from these two binary words a command binary word (3) controlling the means for putting back into phase (5).

12. Device according to claim 11, characterised in that the means for interpolation (30) are constituted from a programmable read only memory.



13. Device according to claim 12, characterised in that the means for putting back into phase (5) comprise circuits (510, 520) for memorising the said command signal (C) between two successive determinations, means (51, 52) for regeneration of the synchronisation signals (H_{S1} , H_{S2}) from the said clock signals (H) and means for conditional selection (53-56) of a synchronisation signal (H_{S2}) regenerated under the control of the said newly determined binary command word (C).

14. Device according to claim 13, characterised in that the said means for conditional selection comprise a bistable element (56) initialised by a transition of a set direction of the newly regenerated synchronisation signals (H_{S2}).