Description

The present invention relates to position control systems; more particularly, position control systems having particular advantages when used in record storage disk recording and player apparatus.

Transducer positioning systems, particularly those used with magnetic or optical disk recording and player apparatus, have used a so-called velocity loop for long transducer motions, termed seeks, i.e., seeks traversing a large number of concentric circular record tracks. The velocity positioning servo mode is optimally switched to a track-following positioning servo mode at one-quarter track pitch from a target track. Such a track-following control may be compared to a "stop-lock" positioning control in other applications of positioning control systems. The track-following position servo then positions the transducer to faithfully track or follow the target track. In a subsequent seek operation, the track-following position loop is interrupted to return to either a velocity loop, a second positioning loop, or an open loop "bang-bang" servo for moving the transducer to yet another target track. It has been found that when the inter-track spacing is reduced to obtain higher track densities, then overshoot and track- settling problems become more acute when the servo mode is switched from velocity mode to track-following mode at the one-quarter track pitch from the target track. Accordingly, it is desired to provide for a more reliable and faster transition from velocity to positioning servo mode which results in faithful yet rapid track-following mode for carried signal transducers.

Many optical recorders have a goal of high performance at low cost. Accordingly, a so-called fine servo or fine actuator is carried upon a head-carrying arm which is moved by a coarse actuator. Typically, the fine actuator has high frequency response characteristics and provides for rapid and short distance positioning of the transducer with respect to a track being followed or for moving from one track to a second target track, which may be an adjacent track. The coarse servo which positions a relatively large mass head-carrying head arm, as well as the fine actuator, typically has frequency characteristics for handling the longer moves for optimizing the relationship for top performance between the fine and coarse actuators. The servo systems provide for relative positioning of the fine actuator with respect to the coarse actuator to a central or reference position. Such arrangements have been colloquially called "piggy back" carriage servo systems.

"Tracking servo for small size optical disk system", H. Inada et al., SPIE, Vol. 695, Optical Mass Data Storage II (1986), discloses a two-stage servo system and tracking error integration memory for improving track access time and data transfer rate.

EP 0 149 888, on which the preamble of claim 1 is based, discloses a servo control system for moving an optical system mounted on a fine tracking actuator which is mounted on a coarse position actuator. The servo control system, in operation, control the movement of the fine tracking actuator through a first servo control loop, and the coarse position actuator through a second servo control loop. The servo control system is operable simultaneously to position both the fine tracking actuator and coarse position actuator by operating said first and second servo control loops in response to a difference between actual and desired positions of the optical system.

The application of such a "piggy back" carriage system is not limited to disk recorders. Actually, the concept was established many years ago for a pattern following or template-controlled coarse-fine positioning servo mechanism. Such an arrangement enabled higher production rates of a pattern controlled machine, such as welding machines or cutting machines. The carried fine actuator rapidly responds to sharp changes in the pattern such that the welding or cutting operation faithfully follows the guiding pattern template while only overcoming minimal inertia of the pattern controlled machine mechanisms. Gardiner, U.S. patent 2,717,979 shows such an arrangement. Gardiner teaches that the fine actuator, which Gardiner terms a topping servo, is controlled by the absolute positioning of the pattern template; while the coarse servo (called the main servo by Gardiner) is slaved to (always follows) the positioning of the topping servo. This arrangement means that the rapid responding topping servo controls the pattern controlled machine while the main servo follows the motions of the topping servo for maintaining the topping servo in an optimumal position with respect to the main servo controlled carriage; thereby maximizing the range of operation of the topping servo. The Gardiner positioning servo arrangement is also shown in Meyer, U. S. Patent 4,627,039.

McIntosh et al., U. S. Patent 3,924,268 and Merritt et al, U. S. Patent 4,513,332 show magnetic disk recorders having piggy-back arrangements which are servo position controlled for optimizing the relative position of the fine actuator with respect to the coarse actuator. Simons, in U. S. Patent 3,924,063 shows yet another coarse-fine control wherein the fine actuator is permitted to move over a predetermined minimum distance before a coarse actuator operation is invoked. Van Winkle in U. S. Patent 4,191,981 shows fast and slow servo positioning mechanisms in a magnetic multiple disk recorder in which the slow servo mechanism is slaved to the fast servo mechanism; the latter arrangement is not a piggy-back arrangement.

Coarse and fine actuator controls are also widely found, particularly in magnetic disk recorders, for controlling a single carriage. In many instances, the fine control is a position responsive servo while the

coarse or seek control is a velocity responsive servo. In some instances, both servo controls use position responsive controls. Examples of such coarse-fine controls of both types are shown in Svendsen U. S. Patent 4,268,785; Kaser et al., U. S. Patent 4,032,984; Case, U. S. Patent 4,103,314; Sordello, U. S. Patent 3,458,785; and Johnson, U. S. Patent 4,333,117. Coarse and fine controls are also shown for optical recorders by van Rosmalen in U. S. Patent 4,425,043 and by Janssen et al. in U. S. Patent 4,561,081.

Not all positioning systems employ two separate servo mechanism control loops. An example of a single loop control for both track seeking and track-following is shown by Matia et al. in U. S. Patent 4,217,612. Matia et al. employ a single position mode servo which includes an analog summer circuit, which during the track-following mode, has a control input of a reference potential. For track switching or seeking, a track increment generator supplies an input central signal to the summer circuit for actuating the loop to move the head or transducer carriage radially of a disk to another track position. In particular, see Figs. 1 and 7 in this reference for a single loop controller which not only track follows, but uses the same track-following loop for moving a transducer in a seek operation over a plurality of concentric record tracks.

Newell, in U. S. Patent 2,800,769, shows a gun-directing servo as yet another coarse-fine control. The fine control controls the hydraulic speed gear of the gun directing or laying servo similar to track-following in a disk recorder. A coarse control is responsive to an input signal for supplying a relatively large servo driving signal. This driving signal is coupled to a switch in the servo loop which switches between fine and coarse controls. When the coarse output signal is relatively large, the switch responds to the large signal amplitude to switch from the fine to the coarse control. When the output signal of the coarse control is reduced below a given threshold, then the switch returns the servo from the coarse control to the fine control. The gun-directing servo apparently has a 360 degree rotational range. The fine control positions the hydraulic speed gear within a 2-1/2 degree error, which is about 0.7% of the positioning range. Based upon this small position error range of the fine control, it is believed that this fine control corresponds favorably to track-following in disk recorders. Another aspect of the Newell arrangement is a rate sensor which supplies a rate signal for assisting in deceleration of the hydraulic speed gear toward the target rotational position.

Optical recorders of both the record disk and record sheet (also termed tablet or chip) type have employed servo positioning wherein the light phase between adjacent tracks of optical indicia are reversed; that is, between adjacent record tracks 1 and 2 a black or opaque line extends for controlling the servo positioning. Between adjacent tracks 2 and 3, a transparent line extends between these adjacent tracks. Between tracks 3 and 4, the opaque line is repeated, etc. Track following uses a grey scale representing a mid point between the opaque and transparent track guiding lines. The reversal relationship of the opaque and transparent lines constitute a phase reversal in positioning control. Such an arrangement is shown by King et al. in U. S. Patent 2,843,841. King et al. shows interrupting track-following mode for seeking to an adjacent track, also termed "track jumping". According to King et al., an open-loop pulse is applied to the positioning servo circuits for moving an optical radiation beam toward an adjacent target track. The open-loop pulse is designed to move the beam just over one-half way between two adjacent tracks. At this time, the phase of the servo circuits is reversed and the open loop pulse terminates. At this time, the track-following servo takes over the control of the radiation beam positioning for moving it to the target adjacent track in a track-following mode. Jensen, in U. S. Patent 3,473,164, uses the arrangement for servo positioning shown in King et al., but uses a different servo control mechanism for moving the radiation beam from one track to an adjacent track. Reversal of the servo phase is also employed by Jensen for jumping the radiation beam to an adjacent track.

Even with all of the above variations of servo positioning of a transducer or work object with respect to a record element (disk, sheet or other work element), it is desired to provide for a more rapid and faithful servo positioning, particularly for data recorders having extremely high track densities. It is desired to provide for a more faithful so-called track "capture" such that the servo mode can switch from seeking to track-following more rapidly and reliably. A problem found in using high track densities is that as the transducer is radially moved slower and slower, the disk run-out caused by eccentricity of the disk with respect to its rotating spindle, causes radial motions of the track with respect to the slow moving transducer. Accordingly, an engineering problem of faithfully measuring radial speed of the transducer with respect to the tracks (which are relatively radially moving inward or outward, depending upon eccentricity) becomes more difficult as well as faithful counting of the track crossings for precisely determining radial position with respect to the radially moving tracks, becomes more difficult. It is also desired to use a velocity servo loop for the long seeks.

Accordingly the present invention provides a position servo system having an actuator movably mounted on a support and carrying a working object transducer to be positioned over a predetermined travel path with respect to a work element and being disposed in operative relationship to the work element, the work element having a plurality of spaced-apart position-indicating indicia along said predeter-

mined travel path and being sensible by the working object such that the working object supplies a local position indication of the positional relationship between the working object and any indicium currently being senses, position error means being operatively connected to the working object for receiving said indication and for supplying a position error signal indicative of a position of the working object relative to a target indicium, the system comprising a velocity servo circuit (106) operatively connected to the position error means and the actuator (46) for controlling the actuator to move the working object towards a target indicum; characterised by a position servo circuit operatively connected to said error means and to the actuator for controlling the actuator to maintain the working object in a predetermined relationship to an indicium currently being sensed by the working object and upon command to move the working object along said predetermined path to a first target indicium within a predetermined number of indicia from the current indicium; the velocity servo circuit being operatively connected to the position error means and to the actuator for controlling the actuator to move the working object a number of indicia from the current indicium greater than said predetermined number of indicia along said predetermined path toward a second target indicium; and switching means operatively interposed between said servo circuits and said actuator for enabling the velocity servo circuit to control the actuator for all movements of the working object over indicia spaced from said second target indicium more than said predetermined number of indicia along the predetermined path and for switching control of the actuator from the velocity servo circuit to the position servo circuit when the working object is not more than said predetermined number of indicia from said second target indicium.

A fine actuator/carriage is mounted for relative movement upon a coarse actuator/carriage for positioning movement along a path over a set of serially arranged positioning indicia. In a disk recorder, the positioning indicia can be record tracks on a disk surface. Such record tracks can be indicated by grooves in the record surface, opaque/transparent areas and the like. In every seek for traversing more than a certain number of indicia or tracks, a velocity servo circuit controls the motion of the fine actuator for rapidly positioning the fine actuator with respect to the positioning indicia. A position to the fine actuator for maintaining position of a work object (transducer or work element) carried on a fine actuator carriage with respect to a first position-indicating indicium on a track in the positioning path. The positioning servo circuit incudes short movement means for causing the fine actuator to move the work object over not more than said first number of the positioning indicia to another indicium from the first indicium. The short movement means in the position servo circuit extends the range of operation of the position servo circuit from operating with but one indicium to a range of several indicia. Switching means are connected to the two servo circuits for selectively connecting the servo circuits to the fine actuator. For maintaining the fine actuator over the first indicium and for short seeks or movements to other indicia within a predetermined range, the position servo circuit is actuated. For longer seeks or movements over a large number of position indicia, the velocity circuit is actuated to move the work object or transducer over the indicia. When the work object is moving toward a target indicium over an indicium at about the outer extent of the range of operation of the position servo circuit with respect to a target indicium, the switching means switches the control of the positioning from the velocity servo circuit to the position servo circuit for completing the seek and to achieve later track capture to a target indicium at one-quarter pitch from the target indicium.

In a preferred mode, the position servo circuit is actuated for following the velocity servo circuit positioning control such that when the outer extremity of the position servo circuit range is reached, the servo drive signal from both the position and velocity servo circuits, are similar or identical. Switching from velocity to position mode control then becomes easy for enabling the position servo circuit to rapidly and faithfully finish the seek to the target indicia. In a particular embodiment, a comparator is connected to both position and velocity servo circuits for comparing their respective output servo drive signals. When the signals are identical, the comparator actuates the switching means to switch from the velocity mode to the position servo mode.

In another aspect of the invention, the velocity and position servo circuits operate to control a fine actuator carried by a coarse actuator. The coarse actuator is slaved to the positioning of the fine actuator through a position control servo circuit. The servo drive signal to the fine actuator is fed forward through a coupling circuit to the coarse positioning circuit for enabling more faithful following of the coarse actuator to the fine actuator for movements during seeking.

An embodiment of a position servo according to the present invention may comprise a system a coarse actuator carrying a fine actuator, the fine actuator being movably mounted on the coarse actuator along a first axis, a frame supporting the coarse actuator for movement along the first axis, relative position detection means (RPS) operatively connected to the fine and coarse actuators for indicating the relative position with respect to a reference position relative of the fine actuator to the coarse actuator; absolute position detection means operatively connected to the frame and the fine actuator for indicating a relative position of the fine actuator to the frame; the improvement including, in combination: a first posi-

tioning servo loop connected to the fine actuator and to said absolute position detection means for supplying a servo drive signal to the fine actuator to control short relative motions between the fine actuator and the frame; a velocity positioning servo loop connected to the fine actuator and to said absolute position detection means for supplying a servo drive signal to the fine actuator to control long relative motions between the fine actuator and the frame; control means connected to said first and velocity positioning loops to switch control there between respectively for said short and small relative motions between said fine actuator controlling the actuator between said frame; and a second positioning servo loop connected to the coarse actuator and to said RPS position detection means for controlling motions of the coarse actuator such that the relative position of the fine actuator with respect to the coarse actuator during positioning motions of the fine actuator controlled by either said first and velocity positioning servo loops is continuously servoing toward said reference relative position.

A further embodiment of the present invention may comprise feed forward means operatively intercoupling said fine actuator and said second positioning servo loop for supplying a servo positioning alteration signal such that said second positioning servo loop supplies a higher amplitude signal to coarse actuator for preventing the fine actuator from being displaced from said reference relative position greater than a predetermined distance whereby the coarse actuator moves faster during periods of time that that fine actuator is being strongly actuated by either of said first or velocity positioning servo loops.

A still further embodiment of the present invention may comprise distance to go means in said control means for supplying a motion command indicating direction of motion and distance to go from a current relative position of the fine actuator and said frame as indicated by said absolute position detection means toward a target relative position of said fine actuator to said frame; output means in the control means being connected to said distance to go means for receiving said motion command and supplying said motion command only to said first positioning servo loop when said distance to go is less than a predetermined range of motion from said target position and quiescing said velocity positioning servo loop for such motion and being further operative when said motion command indicates motion greater than said predetermined range to actuate the velocity positioning servo loop for an initial motion while quiescing the first positioning servo loop; and mode change means in the control means operatively coupled to said absolute detection means for receiving an indication therefrom that said relative position is actuating the fine actuator and causing said first position servo loop to complete the motion to the target relative position within said predetermined range.

A further embodiment of the present invention can be realised wherein said first positioning servo loop having a stop lock mode for maintaining relative position of the fine actuator with respect to said frame and a seek mode operative within said predetermined range and operating under a first positioning motion profile when switching form said velocity positioning servo loop to the first positioning servo loop including a profile beginning at an amplitude corresponding to the amplitude of the servo drive signal of the velocity positioning servo loop and declining to a reference potential usable in said stop lock mode; and a second position motion profile when seeking from initial stop-lock position which increases an amplitude to a predetermined value at a target position and having means for reducing the profile to said reference potential at said target position.

A still further embodiment of the present invention can be realised wherein said absolute position detection means supplying a digital number indicative of distance to go; said control means being operatively coupled to said absolute position detection means for indicating a commanded distance to go and supplying the indication to said absolute position detection means; said absolute position detection means, including down counting means, down counting from said commanded distance to go toward zero, which represents reaching a target position; wherein each down count of said absolute position detection means is representative of an addressable stop-lock position of the fine actuator with respect to the frame as maintainable by said first positioning servo loop; and means in the control means limiting said predetermined range to not being less than two of said stop lock positions.

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

Brief Description of Drawings

Fig. 1 is a simplified block and diagrammatic showing of an optical disk recorder in which the present invention may be advantageously employed.

Fig. 2 is a simplified block and diagrammatic showing of a preferred implementation of the invention in the fig. 1-illustrated recorder.

Fig. 3 is a graph illustrating a seek operation controlled by the fig. 2-illustrated servo circuits.

Fig. 4 is a graph showing operation of the fig. 2-illustrated circuit switching from velocity to position modes of servo operation.

Fig. 5 is a block and diagrammatic detailed showing of fig. 2-illustrated servomechanism.

Fig. 6 is a simplified block diagram of a coarse position circuit used in the fig. 5 illustration.

Detailed Description

Referring now more particularly to the appended drawings, like numerals indicate like parts of structural features shown in the various figures. Referring particularly to Fig. 1, a magnetooptic record disk 30 is mounted for rotation on spindle 31 by motor 32. The optical elements 33 on head arm carriage generally denoted by number 34 move radially of disk 30. A frame 35 of the recorder suitably mounts carriage 34 for reciprocating radial motions. The radial motions of carriage 34 enable access to any one of a plurality of concentric tracks or circumvolutions of a spiral track for recording and recovering data on and from the disk. Linear actuator 36, suitably mounted on frame 35, radially moves carriage 34 for enabling the track accessing. The recorder is suitably attached to one or more host processors 37, such host processors may be control units, personal computers, large system computers, communication systems, image processing processors and the like. Attaching circuits 38 provide the usual logical and electrical connections between the optical recorder and the attaching host processors 37.

Microprocessor 40 controls the recorder including the attachment to the host processor 37. Control data, status data, commands and the like are exchanged between attaching circuits 38 and microprocessor 40 via bidirectional bus 43. Included in microprocessor 40 is a program, or microcode, stored in read only memory (ROM) 41 and a data and control signal storing random access memory (RAM) 42. This microcode enables microprocessor 40 to operate the recorder and for effecting other machine operations usually employed in signal recorders.

The optics of the recorder include an objective or focusing lens 45 mounted for focussing and tracking motions on head arm 33 by fine actuator 46. Actuator 46 includes mechanisms for moving lens 45 toward and away from disk 30 for focussing as well as radial movements for track-following and seeking movements. Numeral 47 denotes the two-way light path between lens 45 and disk 30. The coarse actuator continually follows the fine actuator for monitoring, as much as possible, the fine actuator at the radial center of the fine actuator's range of motion. In magnetooptic recording, magnet 48 provides a magnetic steering or bias field for controlling the remnant magnetization direction of a small spot on disk 30 illuminated by laser light from lens 45. The laser light spot heats the illuminated spot on the record disk to a temperature above the Curie point of the magnetooptic layer (not shown, but can be an alloy or rare earth and transitional metals as taught by Chaudhari et al., U. S. Patent 3,949,387). This heating enables magnet 48 to direct the remnant magnetization to a desired direction of magnetization as the spot cools below the Curie point temperature. Magnet 48 is shown as oriented in the "write" direction, i.e., binary ones recorded on disk 30 normally are "north pole remnant magnetization". To erase disk 30, magnet 48 rotates for moving the south pole adjacent to disk 30. Control 49 for magnet 48 is mechanically coupled to rotatable magnet 48 as indicated by dashed line 50 to control the write and erase directions. Magnet 48 may be replaced by an electric coil wherein the electrical current directions are reversed for write and erase operations. Microprocessor 40 supplies control signals over line 51 to control 49 for effecting reversal between the recording and erasing magnetic directions.

It is necessary to control the radial position of the beam following path 47 such that a track or circumvolution is faithfully followed and that a desired track or circumvolution is quickly and precisely accessed. To this end, focus and tracking circuits 54 control both the coarse actuator 36 and fine actuator 46. The positioning of carriage 34 by actuator 36 is precisely controlled by control signals supplied by circuits 54 over line 55 to actuator 36. Additionally, the actuator control by circuits 54 is exercised by control signals travelling over lines 57 and 58 respectively for focus and fine tracking and track switching actions of fine actuator 46.

The focus and tracking position sensing is achieved by analyzing laser light from laser 67 reflected from disk 30 over path 47, thence through lens 45, through one-half mirror 60 and to be reflected by half-mirror 61 to a so-called "quad" detector 62. Quad detector 62 has four photo elements which respectively supply signals on four lines collectively denominated by numeral 63 to focus and tracking circuits 54. Quad detector 62 also includes optics such as semicylindrical lens for optically processing the light beam for effecting focus error detection. Aligning one axis of the detector 62 with a track center line, track- following operations are enabled. Focussing operations are achieved by comparing the light intensities detected by diagonal photo elements in the quad detector 62. Focus and tracking circuits 54 analyze the signals on lines 63 to control both focus and tracking.

Recording or writing data onto disk 30 is next described. It is assumed that magnet 48 is rotated to the desired position for recording data. Microprocessor 40 supplies a control signal over line 65 to laser control 66 for indicating that a recording operation is to ensue. This means that laser 67 is energized by control 66 to emit a high intensity laser light beam capable of heating a spot on the medium to the Curie point for recording signals; in contrast, for reading recorded signals, the laser 67 emitted laser light beam is a much reduced intensity which does not heat the laser illuminated spot on disk 30 above the Curie point. Control 66 supplies its control signal over line 68 to laser 67 and receives a feedback signal over line 69 indicating the laser 67 emitted light intensity. Control 68 adjusts the light intensity to the desired value, de-

pending on whether a write operation is occurring. Laser 67, a semiconductor laser such as a gallium arsenide diode laser, can be modulated by data signals so the emitted light beam represents the data to be recorded by such intensity modulation. In this regard, data circuits 75 (later described) supply data indicating signals over line 78 to laser 67 for effecting such modulation. This modulated light beam passes through polarizer 70 (linearly polarizing the beam), thence through collimating lens 71 toward half-mirror 60 for being reflected toward disk 30 through lens 45. Data circuits 75 are prepared for recording the microprocessor 40 supplied suitable control signals over line 76. Microprocessor 40 in preparing circuits 75 is responding to commands for recording received from a host processor 37 via attaching circuits 38. Once data circuits 75 are prepared, data is transferred directly between host processor 37 over bus 77 into data circuits 75 through attaching circuits 38. Data circuits 75 also include ancillary circuits (not shown) relating to disk 30 format signals, error detection and correction and the like. Circuits 75, during a read or recovery detection, strip the ancillary signals from the readback signals before supplying corrected data signals over bus 77 to host processor 37 via attaching circuits 38. A data buffer (not shown) in data circuits 75 provides data buffering, as is well known for DASDs. During a reading operation, MO detector 79 converts the two phases of polarized light into data signals; the data signals are fed to data circuits 75.

Reading or recovering data from disk 30 for transmission to a host processor requires optical and electrical processing of the laser light beam from the disk 30. That portion of the reflected light (which has its linear polarization from polarizer 70 rotated by disk 30 recording using the Kerr effect) travels along the two-way light path 47, through lens 45 and half mirrors 60 and 61 to the data detection portion 79 of the head arm 33 carried optics. Half-mirror or beam splitter 80 divides the reflected beam into two equal intensity beams both having the same reflected rotated linear polarization. The half-mirror 80 reflected light travels through a first polarizer 81 which is set to pass only that reflected light which was rotated when the remnant magnetization on disk 30 spot being accessed has a "north" or binary one indication. This passed light impinges on photocell (P) 82 for supplying a suitable indicating signal to differential amplifier 85.

When the reflected light was rotated by a "south" or erased pole direction remnant magnetization, then polarizer 81 passes no or very little light resulting in no active signal being supplied by photocell (P) 82. The opposite operation occurs by polarizer 83 which passes only "south" rotated laser light beam to photocell (P) 84. Photocell 84 supplies its output signal indicating its received laser light to the second input of differential amplifier 85. The amplifier 85 supplies the resulting difference signal (data representing) to data circuits 75 for detection. The detected signals include not only data that is recorded, but also all of the so-called ancillary signals as well. The term data as used herein is intended to include any and all information-bearing signals, preferably of the digital or discrete value type. Other forms of information signal recording may be used.

The rotational position and rotational speed of spindle 31 is sensed by a suitable tachometer or emitter sensor 90. Sensor 90, preferably of the optical-sensing type that senses dark and light spots on a tachometer wheel (not shown) of spindle 31, supplies the "tach" signals (digital signals) to APS (angular or rotational position sensing) circuit 91 which detects the rotational position of spindle 31 and supplies rotational information-bearing signals to microprocessor 40. Microprocessor 40 employs such rotational signals for controlling access to data storing segments on disk 30 as is widely practiced in the magnetic data storing disks. Additionally, the sensor 90 signals also travel to spindle speed control circuits 93 for controlling motor 32 to rotate spindle 31 at a constant rotational speed. Control 93 may include a crystal controlled oscillator for controlling motor 32 speed, as is well known. Microprocessor 40 supplies control signals over line 94 to control 93 in the usual manner.

For the Fig. 1-illustrated embodiment to follow the "Gardiner" servo positioning approach, sensor 97 is mounted on carriage 34 and is operatively coupled to fine actuator 46, as diagrammatically indicated by dashed line 98. The operative coupling is preferably an optical communication path. For example, fine actuator 46 carries an opaque/transparent flag or reflective/transparent flag. Sensor 97 shines a light toward the flag with the transmitted or reflected light being intercepted by photocells (not shown) of sensor 97, which faithfully indicate the relative radial position of fine actuator 46, with respect to carriage 34. Sensor 97 includes circuitry of known design that translate the intercepted light into a relative position indicating signal (RPS) traveling over electrical line 99 to focus on tracking circuits 54. The relative position signal on line 99 actuates focusing and tracking circuits 54 to slave the movement of head carriage 34 by actuator 36 through signals supplied over line 55, as will be later detailed.

Referring more particularly now to Fig. 2, focus and tracking circuits 54 operation is described with respect to the control of actuator 46 and the position controls of working object or lens 45 with respect to the record disk or work element 30. Focus and tracking circuits 54 include two track servo circuits, 105 and 106, respectively of the position and velocity servo type. Position servo circuit 105 not only controls actuator 46 to ensure that lens 45 faithfully follows (also termed a "stop-lock" mode) a record track on disk 30, but also has an extended range of radial operation for controlling lens 45 positioning over a plur-

ality of record tracks of disk 30.

For example, the extended range of position servo circuit 105 may be plus and minus ten tracks of a current track being followed. With respect to a current track being followed, for seeks of radiation beam 47 over a number of record tracks greater than ten, velocity servo circuit 106 controls actuator 46. Electronic switch 107 selectively transfers the servo drive output signals of circuits 105 and 106 over line 57 to fine actuator 46. Switch 107 is controlled such that on a long seek (more than ten tracks are traversed) the switch electrically connects input terminal V, which carries the velocity servo drive signal from line 109, to line 57. When radiation beam 47 is approximately ten tracks from the target track, then switch 107 disconnects terminal V from line 57 and reconnects terminal P to transfer the position servo circuit 105 servo drive signal over line 57 to actuator 46. This latter connection enables the position servo circuit 105 to utilize its extended range of operation to faithfully and quickly complete the long seek to the target track. Switching from terminal V to terminal P is performed when the drive signals from circuits 105 and 106 are approximately equal. To effect this switching synchronization, power compare circuit 108 receives the respective servo drive signals over lines 109 and 110 for comparing the RMS (root mean square) parameter of the signals. Such comparison is a well known technique and not described for that reason. When power compare circuit 108 detects approximate equality of the two servo drive signals, it emits a mode-changing signal over line 113 for actuating switch 107 to disconnect terminal V and reconnect terminal P to output line 57. Line 113 also extends to velocity servo circuit 106 for quiescing the signal compensation circuits therein, as is well known.

Compare circuit 108 is activated when laser beam 47 is approaching the outer extremity of the range of operation of position servo circuit 105. Such positioning is indicated by track counter 111 which was initially set by microprocessor 40 to indicate a direction of motion and number of record tracks (position indicia) to be traversed during the seek. Cable (electronic bus having a plurality of electrical circuit lines) 116 carries the distance to go and direction signals to track counter 111, as well as to velocity servo circuit 106. Velocity servo circuit 106 responds to the distance to go signal to set up a mode of operation optimizing the seek operation. Track counter 111 detects when the track count is approaching ten for supplying a compare circuit 108 activating signal over electrical line 112. Compare circuit 108 responds to the line 112 signal for comparing the servo drive signals on lines 109 and 110, as above described. Line 112 also extends to position servo circuit 105 for activating same to follow the positioning of radiation beam 47 as effected by velocity servo circuit 106; that is, circuits 105 now produce a servo drive signal for use by a compare circuit 108. Track counter 111 supplies the current track count over cable 114 to microprocessor 40 and position servo circuits 105 and 106. Circuits 105 and 106 use the track count in a usual manner.

A track seek operation is initiated under control of microprocessor 40. Microprocessor 40 supplies a seek initiate signal over line 115 which extends to switch 107 and circuits 105 and 106. For a short seek, the seek signal keeps switch 107 connected to the P terminal such that position servo circuit 105 controls the seek operation through its extended range of operation. The line 115 seek signal activates position servo circuit 105 in the short seek, while in a long seek quiesces a later shown signal compensation circuit in preparation for the track seek mode switch. The seek command also goes to velocity servo circuit 106 for activating same for a long seek, as will become apparent. All seeks are completed by position servo circuit 105 entering a track-following or stop-lock mode. When the track-following operation begins, circuit 105 supplies a seek complete signal over line 117 to microprocessor 40. Coordination of the operation of the track counter 111 and circuits 105 and 106 is through the position error signal supplied over line 63 from detector and optics 79. Fig. 4 illustrates the spatial synchronization of circuit operation using the PES signal not only for track-following and position servo seeking, but also track counting.

Fig. 3 broadly illustrates a seek operation using both velocity and position servo circuits in a move from a current track centerline C to a target track centerline T. The graph is in the space domain; does not illustrate the signals in any time base. The beam 47 velocity or speed curve with respect to the recording surface of disk 30 is illustrated by line 120. Velocity, of course, begins at zero and proceeds to a maximum value whereas deceleration begins toward and follows line 122 to track T. The velocity servo circuit 106 servo drive signal is represented by dashed line 121 which effects the resultant velocity signal curve 120. During deceleration, numeral 122 designates that the velocity curve 120 and velocity servo circuit 106 servo drive signal are coincident. When track counter 111 contains a count TK equal to K (K is ten in the preferred embodiment), track counter 111 emits its compare enable signal over line 112 which corresponds to dashed line 123 in Fig. 3. At this time, the position servo circuit 105 servo drive signal POS is turned on as indicated by signal wave 124. Signal wave 124 follows the deceleration curve 122 at spatial line 125. Compare circuit 108, detecting that the RMS value of POS signal 124 is equal to the velocity servo circuit 106 servo drive signal VEL on line 109, actuates switch 107 to disconnect the V terminal from and connect the P terminal to actuator 46. Since the RMS amplitudes of the signals on line 109 and 110 are substantially identical, no transients are introduced into the oper-

ation of actuator 46. The power compare circuit 108 signal on line 113 also quiesces the operation of velocity servo circuits 106 as indicated in Fig. 3 by dashed line 126.

The detection of the position of beam 47 during the track seek is enabled by the line 63 (position -- tracking-- error signal) PES 129, as best seen in Fig. 4. PES 129 is shown in the spatial domain as a sine wave with positive going zero crossings at the various track center lines T-10 through T+1. The negative going zero crossing occurs at the midpoint between two adjacent track centerlines. Track counter 111 includes a zero crossing detector for counting the track crossings. Two zero crossings are counted for each traversal of a track. As later described, PES 129 is differentiated to create signal PES' 130. Of course, differentiation causes an effective phase shift of 90 degrees. For position servo circuit 105 to fully utilize the position error signal, the negative signal portions 131, also shaded, are inverted to become positive between the successive zero crossings 156 intermediate adjacent track centerlines. Zero crossings 156 correspond to the one-quarter point between adjacent tracks. POS signal 124 is enlarged in Fig. 4 for showing its relationship to PES 129 and PES' 130. Dashed line 123 of Fig. 3 is shown as being coincident with the centerline of track T-10, i.e., ten tracks to go to target track T, no limitation thereto intended. Dashed line 125 is shown as occurring asynchronously with respect to the PES 129, i.e., independent of the actual radial position of beam 47 with respect to any track centerline. If desired, the transition can be synchronized to such track centerlines. The line 112 signal is shown immediately below the signal POS 124. At the one-quarter track pitch position before beam 47 reaches the track centerline of track T, the line 112 signal is removed.

Position servo circuit 105 not only provides for terminating a long seek and track-following, but also provides for jumping one track, i.e., to an adjacent track as well as providing short seeks up to ten tracks from a current track. Numeral 133 designates such a single track jump from target track T to new target track T+1. The mode switching from track-following to jumping occurs at maximum amplitude of PES 124. Signal 133 ramps as a sawtooth wave with maximum amplitude at about the centerline of T+1 whereupon it relaxes to zero amplitude. The operation is such that the POS control signal 133 and a later described error signal which results in the servo drive closely follows signal 133 such that relatively small signal amplitudes are always present within position control circuit 105. See the Fennema application for patent, supra.

Referring now more particularly to Fig. 5, the detailed discussion is provided for a currently preferred embodiment of the invention. The microprocessor 40 seek command line 115 actually consists of two electrical signal lines, 138 and 139. Electrical line 138 carries a seek command irrespective of the length of the seek for setting seek latch or flip-flop 140. Seek latch 140 being set to the seek condition, conditions position servo circuit 105 for its extended range operation, as will become apparent. The line 139 signal identifies a seek longer than ten tracks, i.e. a long seek. The long seek signal travels over line 139 for setting velocity mode latch 141, which in turn actuates electronic switch 107 to move from the track-following P position to the long seek velocity drive position V. Line 139 also extends to velocity servo circuit 106 for enabling the circuit for performing a long seek operation. Circuit 106 can be of any velocity circuit design and is not described for that reason. The long seek signal activates circuit 106 to receive and respond to the commanded distance-to-go number of tracks supplied by microprocessor 40 over cable 116 as well as the current number of tracks to go as supplied by track counter 11 over cable 114. Velocity mode latch 141 supplies a first output indicating the velocity mode over line 142 as one condition of actuation of power compare circuit 108. To this end, analog AND circuits 143 and 144 are electrically interposed respectively between lines 110 and 109. The enablement of AND circuits 143 and 144 is completed by the line 112 signal (Fig. 4) for supplying an input to compare circuit 108, which operates as previously described.

Track counter 111 responds to the line 63 PES signal 129 through zero crossing detector (0X) circuit 147. OX circuit 147 supplies two pulses for each track crossing to track counter 111 which responds thereto for down counting the tracks to go. A direction signal derived from the detector (not shown) may be used for controlling the directional count of track counter 111. In the present embodiment, because of the extended range of operation of position servo circuit 105, the velocity of beam 47 with respect to the surface of disk 30 always has a sufficient velocity to accommodate run-out. The zero crossing signals from OX circuit 147 also are directed to AND circuit 148 for resetting velocity mode latch 141 to the position mode state. AND circuit 148 is enabled to pass a single zero crossing pulse by the line 112 signal and velocity mode latch 141 being set to the velocity mode state (VS). The AND circuit 148 output signal travels over line 149 thence through AND circuit 150, as enabled by the line 113 signal received from compare circuit 108, to reset velocity mode latch 141. This action by the connection over line 145 to electronic switch 107 actuates the switch to disconnect terminal V and line 109 from line 57 and reconnect terminal P and line 110 to line 57. Line 145 also extends to later described EPROM 170 within circuit 105.

The detailed operation and construction of position servo circuit 105 are next described. The line 63 PES signal 129 is differentiated by differentiator (DIFF) 153 to produce the PES' 130. PES' 130 goes

to polarity reversing circuit 154. Circuit 154 includes zero crossing detector (0X) 155 which detects the zero crossings 156 of PES' 130. AND circuit 157 receives the zero crossing 156 indicating signals and when enabled by the seek signal on line 160 and the line 112 signal from track counter 111, actuates electronic switch 158 to disconnect the plus terminal from its output to signal integrator 164 and connect the minus terminal thereto. The plus terminal directly connects the output of differentiator circuit 153 to integrator 164. The minus terminal connects the output of differentiator 153 through signal inverter or polarity reversing amplifier 159 to integrator 164. Inverter 159 inverts the polarity of negative signal portions 131 of PES' 130. The unipolar PES' signal is integrated by integrator 164 then applied to analog summer circuit 165, thence compensator 166. Compensator 166 supplies the position servo circuit servo drive signal over line 110. Compensator 166 is designed, using known techniques, to enable maximum bandwidth with adequate stability margins, as is common in the servo art.

The control signal for summer 165 to be mixed with the position (tracking) error signal from integrator 164 is generated by a self-sequencing EPROM 170. EPROM 170 is activated by the line 145 signal indicating the position servo mode. Track counter 111 supplies the number of tracks to go to EPROM 170 over cable 114. When track counter 111 has a zero track count, then EPROM 170 causes position servo circuits 105 to be in a track-following mode. The line 160 seek signal also goes to EPROM 170 for ensuring that circuit 105 remains in the track-following mode in the absence of a seek signal irrespective of the numerical contents of track counter 111. EPROM 170 is programmed to generate a position drive signal in the digital form which is supplied over cable 172 to digital analog convertor (DAC) 171. DAC 171 in turn supplies the analog position command signal to summer 165. EPROM 170 includes an electronic table representing the desired position reference signals in digital form for each track count received from track counter 111. The generation of such tables in operations of EPROM are sufficiently well known so that detailed description may be dispensed with.

The seek complete signal to be supplied over line 117 to microprocessor 40 is generated by AND circuit 175. The one-quarter track position from target track T is indicated by the zero crossing signal carried over line 176 from OX 155. EPROM 170 supplies a signal over line 177 indicating that the position of beam 47 with respect to track T centerline is approaching the one-quarter track pitch position, as shown in Fig. 4. AND circuit 175 responds to the two signals to supply the seek complete signal over line 117 which not only goes to microprocessor 40 but also resets seek latch 140 to the off or non-seek condition. Line 177 signal from EPROM 170 corresponds to track counter 111 indicating to EPROM 170 that the number of tracks to go is unity, i.e., the next track is target track T.

Sensor 97 supplies its error signal RPS over line 99 to coarse position servo 180. Line 181 connects the servo drive signal at actuator 46 to coarse position servo 180 as a feed forward signal to ensure that coarse actuator 36 moves head carriage 34 in an optimum manner such that fine actuator 46 follows the center line of a track as closely as possible.

Fig. 6 is a simplified diagram of a coarse position servo circuit 180. Analog summer 185 receives the sensor 97 position error signal over line 99. The position error signal is compared with ground reference potential at ground point 186. The summer 185 error signal is supplied through compensator 187 to analog summer 188. Summer 188 combines the feed forward signal on line 181 with the compensated error signal and supplies a coarse position drive signal through amplifier 189 to coarse actuator 36. Circuit 182 is electrically interposed between line 181 and summer 188 for providing smoothing and amplitude translation of the line 181 carried signal from fine actuator 46.

Claims

1. A position servo system having an actuator (46) movably mounted on a support and carrying a working object (45) to be positioned over a predetermined travel path with respect to a work element (30) and being disposed in operative relationship to the work element (30), the work element (30) having a plurality of spaced-apart position-indicating indicia along said predetermined travel path and being sensible by the working object such that the working object (45) supplies a local position indication of the positional relationship between the working object (45) and any indicium currently being senses, position error means (79) being operatively connected to the working object (45) for receiving said indication and for supplying a position error signal indicative of a position of the working object relative to a target indicium, the system comprising a velocity servo circuit (106) operatively connected to the position error means and the actuator (46) for controlling the actuator to move the working object towards a target indicum;
characterised by
a position servo circuit (105) operatively connected to said error means (79) and to the actuator (46) for controlling the actuator (46) to maintain the working object (45) in a predetermined relationship to an indicium currently being sensed by the working object (45) and upon command to move the working object (45) along said predetermined path to a first target indicium with-

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to polarity reversing circuit 154. Circuit 154 includes zero crossing detector (0X) 155 which detects the zero crossings 156 of PES' 130. AND circuit 157 receives the zero crossing 156 indicating signals and when enabled by the seek signal on line 160 and the line 112 signal from track counter 111, actuates electronic switch 158 to disconnect the plus terminal from its output to signal integrator 164 and connect the minus terminal thereto. The plus terminal directly connects the output of differentiator circuit 153 to integrator 164. The minus terminal connects the output of differentiator 153 through signal inverter or polarity reversing amplifier 159 to integrator 164. Inverter 159 inverts the polarity of negative signal portions 131 of PES' 130. The unipolar PES' signal is integrated by integrator 164 then applied to analog summer circuit 165, thence compensator 166. Compensator 166 supplies the position servo circuit servo drive signal over line 110. Compensator 166 is designed, using known techniques, to enable maximum bandwidth with adequate stability margins, as is common in the servo art.

The control signal for summer 165 to be mixed with the position (tracking) error signal from integrator 164 is generated by a self-sequencing EPROM 170. EPROM 170 is activated by the line 145 signal indicating the position servo mode. Track counter 111 supplies the number of tracks to go to EPROM 170 over cable 114. When track counter 111 has a zero track count, then EPROM 170 causes position servo circuits 105 to be in a track-following mode. The line 160 seek signal also goes to EPROM 170 for ensuring that circuit 105 remains in the track-following mode in the absence of a seek signal irrespective of the numerical contents of track counter 111. EPROM 170 is programmed to generate a position drive signal in the digital form which is supplied over cable 172 to digital analog convertor (DAC) 171. DAC 171 in turn supplies the analog position command signal to summer 165. EPROM 170 includes an electronic table representing the desired position reference signals in digital form for each track count received from track counter 111. The generation of such tables in operations of EPROM are sufficiently well known so that detailed description may be dispensed with.

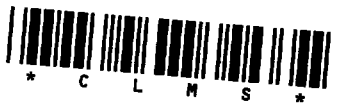
The seek complete signal to be supplied over line 117 to microprocessor 40 is generated by AND circuit 175. The one-quarter track position from target track T is indicated by the zero crossing signal carried over line 176 from OX 155. EPROM 170 supplies a signal over line 177 indicating that the position of beam 47 with respect to track T centerline is approaching the one-quarter track pitch position, as shown in Fig. 4. AND circuit 175 responds to the two signals to supply the seek complete signal over line 117 which not only goes to microprocessor 40 but also resets seek latch 140 to the off or non-seek condition. Line 177 signal from EPROM 170 corresponds to track counter 111 indicating to EPROM 170 that the number of tracks to go is unity, i.e., the next track is target track T.

Sensor 97 supplies its error signal RPS over line 99 to coarse position servo 180. Line 181 connects the servo drive signal at actuator 46 to coarse position servo 180 as a feed forward signal to ensure that coarse actuator 36 moves head carriage 34 in an optimum manner such that fine actuator 46 follows the center line of a track as closely as possible.

Fig. 6 is a simplified diagram of a coarse position servo circuit 180. Analog summer 185 receives the sensor 97 position error signal over line 99. The position error signal is compared with ground reference potential at ground point 186. The summer 185 error signal is supplied through compensator 187 to analog summer 188. Summer 188 combines the feed forward signal on line 181 with the compensated error signal and supplies a coarse position drive signal through amplifier 189 to coarse actuator 36. Circuit 182 is electrically interposed between line 181 and summer 188 for providing smoothing and amplitude translation of the line 181 carried signal from fine actuator 46.

Claims

1. A position servo system having an actuator (46) movably mounted on a support and carrying a working object (45) to be positioned over a predetermined travel path with respect to a work element (30) and being disposed in operative relationship to the work element (30), the work element (30) having a plurality of spaced-apart position-indicating indicia along said predetermined travel path and being sensible by the working object such that the working object (45) supplies a local position indication of the positional relationship between the working object (45) and any indicium currently being senses, position error means (79) being operatively connected to the working object (45) for receiving said indication and for supplying a position error signal indicative of a position of the working object relative to a target indicium, the system comprising a velocity servo circuit (106) operatively connected to the position error means and the actuator (46) for controlling the actuator to move the working object towards a target indicum;
characterised by
a position servo circuit (105) operatively connected to said error means (79) and to the actuator (46) for controlling the actuator (46) to maintain the working object (45) in a predetermined relationship to an indicium currently being sensed by the working object (45) and upon command to move the working object (45) along said predetermined path to a first target indicium with-



in a predetermined number of indicia from the current indicium;

the velocity servo circuit (106) being operatively connected to the position error means and to the actuator (46) for controlling the actuator (46) to move the working object (45) a number of indicia from the current indicium greater than said predetermined number of indicia along said predetermined path toward a second target indicium; and

switching means (107) operatively interposed between said servo circuits and said actuator (46) for enabling the velocity servo circuit (106) to control the actuator (46) for all movements of the working object (45) over indicia spaced from said second target indicium more than said predetermined number of indicia along the predetermined path and for switching control of the actuator (46) from the velocity servo circuit (106) to the position servo circuit (105) when the working object (45) is not more than said predetermined number of indicia from said second target indicium.

2. A position servo system as claimed in claim 1, wherein

said position and velocity servo circuits respectively supplying servo drive signals to the actuator for controlling same; and

said switching means, including signal compare means operatively coupled to said position and velocity servo circuits for separately receiving the respective servo drive signals and for comparing the amplitudes of said servo drive signals, when the amplitudes reach a predetermined amplitude relationship, then said compare means actuates the switching means to switch control from the velocity servo circuit to the position servo circuit if the working object (45) is not more than said predetermined number of indicia from said predetermined indicium.

3. A position servo system as claimed in claim 2, wherein said switching means further includes proximity means operatively coupled to said position error means for receiving said position error signal and being responsive thereto for indicating that the relative position of the working object (45) with respect to said second target indicium is approaching said predetermined number of indicia from said second target indicium and to actuate said compare means to begin comparing said servo drive signals; and

said compare means including inhibit means for inhibiting comparison of the servo drive signals until said proximity means actuates said compare means.

4. A position servo system as claimed in any preceding claim, further including

command means coupled to said switching means for supplying a seek command thereto and to said position and velocity servo circuits for supplying direction and number of indicia to be traversed in reaching a one of said target indicia; and

mode selection means in the command means responsive to a number of indicia to be traversed during a seek less than said predetermined number of actuating the switching means to connect the position servo circuit to the actuator and disconnect the velocity servo circuit from the actuator, and being further responsive to the number of indicia to be traversed being greater than said predetermined number of indicia to actuate the switching means to initially connect the velocity servo circuit to the actuator and enabling the switching means for switching control to the position servo circuit from the velocity servo circuit when the work object is not more than said predetermined number of indicia from said target indicium.

5. A position servo system as claimed in claim 1, further wherein

said position servo circuit includes:

an analog signal summer circuit for supplying a servo drive signal for controlling the actuator and having first and second inputs;

the position servo circuit being connected to said work object for receiving said local position indication;

a signal differentiating circuit receiving said local position indication for differentiating same for supplying a differentiated local position indication;

signal polarity reverse means electrically connecting the differentiating circuit to said summer circuit for transferring the differentiated local position indication to one input of the summer circuit;

the reference potential means connected to the second input to said analog summer circuit for supplying a stop lock reference signal to said summer circuit for maintaining the working object in a stop lock condition over a one of said indicia;

track movement control means for supplying a position servo control signal to said analog summer for replacing the positional reference signal when the position servo circuit is moving the working object within said predetermined number of indicia; and

said command means further including a connection to said position servo circuit for actuating said track movement control means and said polarity reverse means when switching con-

trol of the actuator from the velocity servo circuit to the position servo circuit for synchronously reversing the polarity of the differentiated local position signal with respect to indicia crossings for maintaining a small error signal as said servo drive signal from the position servo circuit to the actuator during position servo circuit controlling operations.

6. A position servo system as claimed in claim 1 or 5, wherein said position error means includes:

a down counter having a count contents representative of a number of indicia to be traversed to reach a one of said target indicia operatively connected to the work object for receiving said local position indication being responsive to said local position indication to down count as the work object passes over indicia in traveling toward a one of said target indicia and generating a count indicating the position error of the work object with respect to the target indicium.

7. A position servo system as claimed in claim 1, further including, in combination:

said position servo circuit including:

control means for controlling operation of the position servo circuit, for causing the position servo circuit to move the working object away from a current indicium by supplying a ramp signal beginning at a reference potential which represents a stop lock condition over a currently positioned indicium and increasing in amplitude representative of a distance between the current indicium and a target indicium and resetting the ramp to a reference potential upon reaching the target indicium, and further including means for supplying a ramp signal in response to the switching means beginning at a maximum amplitude and declining to said reference potential.

8. A position servo system as claimed in claim 1, further including, in combination:

a data recording apparatus including said servo system and having a moveable transducer as said working object, a record medium as said work element; and

a plurality of spaced apart record tracks on the record medium with each track being a one of said location indicia.

9. A position servo system as claimed in claim 1 or 8, further including

a frame in the record apparatus;

said record medium being a disk mounted for rotation on the frame;

said support being a head carriage movably mounted on the frame for reciprocating motions along a radius of said disk;

said actuator and transducer being mounted on said head carriage with the transducer being mounted on the head carriage for radial movements with respect to the disk; and

means for radially moving the head carriage with respect to the disk and means for relatively controlling the actuator and the moving means for the carriage, such that both the transducer and carriage can be simultaneously moved with respect to the disk.

10. A position servo system as claimed in claim 9, further including

coarse servo circuit connected to said moving means for controlling movements of the head carriage;

a relative position sensor on the head carriage and operatively connected to the transducer for indicating relative position of the transducer with respect to the head carriage;

said coarse servo being connected to the relative position sensor for receiving the signal therefrom for actuating the moving means to move the head carriage for servoing the transducer to a reference position on the head carriage; and

an electrical connection between said actuator and said coarse servo circuit for adjusting operation of the coarse servo circuit for feed forwarding signals from said actuator to the coarse servo circuit to move the head carriage faster when the relative position sensor indicates a greater than a predetermined relative displacement between a transducer and a head carriage.

11. A method of positioning a working object along a path on a work element wherein the path has a plurality of sensible spaced-apart location marks;

including the steps of:

detecting the relative position of said working object along said path;

relatively moving the working object along said path from said detected relative position toward a target relative position such that the detected and target relative positions are separated along said path by a first plurality of said marks;

during a first portion of said relative movement controlling the movement according to a predetermined velocity profile;

sensing for a predetermined range relative location along said path displaced from said target mark by a second plurality of said marks, said second plurality being less than said first plurality but greater than two;

upon sensing said range relative location, switching from said predetermined velocity profile to a predetermined position error profile for completing the relative movement of the working

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object along said path to the target mark traversing said second plurality of marks; and

stop locking the working object and work element at the target mark using a predetermined position reference signal.

12. A method as claimed in claim 11;

further including the steps of:

in said sensing step sensing both said predetermined velocity profile and said predetermined position error profile and when the profiles indicate identical movement of the working object, then in said switching step, switching from the predetermined velocity profile of the working object along said path, to the predetermined position error profile.

13. A method as claimed in claim 11, wherein the working relatively moveable with respect to the moving carriage along said path and the moving carriage being moveable also along said path;

further including the steps of:

sensing the relative position of the working object with respect to a reference position with respect to the moving carriage and;

continuously moving the moving carriage for causing the working object to be closest to said reference position on the moving carriage as possible, including any movements while using either the velocity or position error profiles.

14. In a method of relatively moving first and second objects along a predetermined path of relative movement from a first relative position to a second relative position displaced from the first relative position a predetermined distance, path location indicating marks on the second object;

including the steps of:

determining the number of said marks to be moved to achieve a predetermined relative movement of said predetermined distance;

if said number is greater than a first number, then firstly relatively moving said objects according to a predetermined velocity profile until a relative position indicated by a second plurality of marks from said second relative position is reached, then changing control of the movement to a first predetermined positioning control profile which ends in a stop-lock control at said second relative position, said second plurality being less than said first number but greater than two; and

if said number is less than said first number, then relatively moving said objects using a second predetermined positioning control profile including a slope negative with respect to said first predetermined positioning control profile and ending at said stop-lock control.

Patentansprüche

1. Ein Positionierungsservosystem mit einem Stellglied (46), das beweglich an einer Halterung befestigt ist, und das ein Arbeitsobjekt (45) umfaßt, der über einem vorbestimmten Bewegungspfad bezüglich eines Arbeitselements (30) positioniert werden soll, und das in einem operativen Verhältnis zum Arbeitselement (30) angeordnet ist, wobei das Arbeitselement (30) eine Mehrzahl in einem bestimmten Abstand zueinander befindlicher positionsanzeigender Indizien entlang des genannten vorbestimmten Bewegungspfads umfaßt und eine Empfindlichkeit für das Arbeitsobjekt besitzt, wobei diese Empfindlichkeit darin besteht, daß das Arbeitsobjekt (45) eine lokale Positionierungsanzeige des Positionierungsverhältnisses zwischen dem Arbeitsobjekt (45) und einem beliebigen Indiz bereitstellt, das zu diesem Zeitpunkt Messungen darstellt, ein Positionierungsfehlermittel (79), das operativ mit dem Arbeitsobjekt (45) verbunden ist, um diese Anzeige zu empfangen, und um ein Positionierungsfehlersignal bereitzustellen, das die Positionierung des Arbeitsobjekts bezüglich eines Zielindizes anzeigt, wobei das System eine Geschwindigkeitsservoschaltung (106) umfaßt, die operativ an das Positionsfehlermittel und an das Stellglied (46) zur Steuerung des Stellglieds zur Bewegung des Arbeitsobjekts zu einem Zielindiz hin angeschlossen ist; charakterisiert durch
eine Positionierungsservoschaltung (105), die operativ mit dem genannten Fehlermittel (79) und mit dem Stellglied (46) zur Steuerung des Stellglieds (46) verbunden ist, um das Arbeitsobjekt (45) in einem bestimmten Verhältnis zu einem Indiz, das zu diesem Zeitpunkt vom Arbeitsobjekt (45) gemessen wird, zu halten, und um das Arbeitsobjekt (45) auf einen bestimmten Befehl hin entlang des genannten vorbestimmten Pfads von einem aktuellen Indiz zu einem ersten Zielindiz innerhalb einer vorbestimmten Anzahl an Zielindizien zu bewegen;
wobei die Geschwindigkeitsservoschaltung (106) operativ mit dem Positionierungsfehlermittel und dem Stellglied (46) zur Steuerung des Stellglieds (46) zur Bewegung des Arbeitsobjekts (45) um eine bestimmte Anzahl an Indizien vom aktuellen Indiz verbunden ist, wobei diese Anzahl größer ist als die genannte vorbestimmte Anzahl an Indizien entlang des genannten vorbestimmten Pfads zu einem zweiten Zielindiz hin;
wobei sich das Schaltmittel (107) operativ zwischen den genannten Servoschaltungen und dem genannten Stellglied (46) befindet, so daß der Geschwindigkeitsservoschaltung (106) ermöglicht wird, das Stellglied (46) für alle Bewegungen des Arbeitsobjekts (45) über Indizien, die

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vom genannten zweiten Zielindiz mehr als die genannte vorbestimmte Anzahl an Indizien entlang des vorbestimmten Pfads entfernt ist, zu steuern, und zur Umschaltung der Steuerung des Stellglieds (46) von der Geschwindigkeitsservoschaltung (106) auf die Positionierungsservoschaltung (105), wenn sich das Arbeitsobjekt (45) nicht mehr als die genannte vorbestimmte Anzahl an Indizien vom zweiten Zielindiz entfernt befindet.

2. Ein Positionierungsservosystem gemäß Anspruch 1, bei dem folgendes gilt:
die genannte Positionierungsservoschaltung und die genannte Geschwindigkeitsservoschaltung liefern Servoantriebssignale an das Stellglied zur Steuerung desselben; und
das genannte Schaltmittel umfaßt ein Signalvergleichsmittel, das operativ an die genannte Positionierungsservoschaltung und die genannte Geschwindigkeitsservoschaltung gekoppelt ist, um die entsprechenden Servoantriebssignale separat zu empfangen und die Amplituden der genannten Servoantriebssignale zu vergleichen, wenn die Amplituden ein vorbestimmtes Amplitudenverhältnis erreichen, dann betätigt das genannte Vergleichsmittel das Schaltmittel und schaltet die Steuerung um von der Geschwindigkeitsservoschaltung zur Positionierungsservoschaltung, wenn das Arbeitsobjekt (45) um nicht mehr als die genannte vorbestimmte Anzahl an Indizien vom genannten vorbestimmten Indiz entfernt ist.

3. Ein Positionierungsservosystem gemäß Anspruch 2, bei dem das genannte Schaltmittel weiterhin ein Proximitätsmittel umfaßt, das operativ an das genannte Positionierungsfehlermittel gekoppelt ist, um das genannte Positionierungsfehlersignal zu empfangen und daraufhin anzuzeigen, daß die relative Position des Arbeitsobjekts (45) bezüglich des genannten zweiten Zielindizes sich der vorbestimmten Anzahl an Indizien vom genannten zweiten Zielindiz annähert, und um das genannte Vergleichsmittel zu betätigen, um mit dem Vergleich der genannten Servoantriebssignale zu beginnen; und
wobei das genannte Vergleichsmittel ein Sperrmittel zur Sperrung des Vergleichs der beiden Servoantriebssignale enthält, bis das genannte Proximitätsmittel das genannte Vergleichsmittel betätigt.

4. Ein Positionierungsservosystem gemäß allen vorherigen Ansprüchen, des weiteren umfassend:
ein Befehlsmittel, das an das genannte Schaltmittel gekoppelt ist und einen Suchbefehl an dieses Schaltmittel und an die genannte Positionierungsservoschaltung und die genannte Geschwindigkeitsservoschaltung bereitstellt, um Richtung und Anzahl der zu überquerenden Indizien zur Erreichung eines der genannten Zielindizien anzugeben; und ein Modusauswahlmittel im Steuermittel, das auf eine Anzahl von während einer Suchoperation zu überquerenden Indizien reagiert, wobei diese Anzahl geringer ist als die genannte vorbestimmte Anzahl an Betätigungen des Schaltmittels, um die Positionierungsservoschaltung mit dem Stellglied zu verbinden und die Geschwindigkeitsservoschaltung vom Stellglied zu trennen, des weiteren reagierend auf die Anzahl der zu überquerenden Indizien, die größer sind als die genannte vorbestimmte Anzahl an Indizien, um das Schaltmittel zu betätigen, um anfänglich die Geschwindigkeitsservoschaltung mit dem Stellglied zu verbinden und dem Schaltmittel zu ermöglichen, die Steuerung von der Geschwindigkeitsservoschaltung zur Positionierungsservoschaltung umzuschalten, wenn das Arbeitsobjekt nicht mehr als die vorbestimmte Anzahl an Indizien vom genannten Zielindiz entfernt ist.

5. Ein Positionierungsservosystem gemäß Anspruch 1, wobei die genannte Positionierungsservoschaltung weiterhin umfaßt:
eine analoge Signalsummiererschaltung zur Bereitstellung eines Servoantriebssignals zur Steuerung des Stellglieds mit einer ersten und einer zweiten Eingabe;
die Positionierungsservoschaltung ist mit dem genannten Arbeitsobjekt verbunden und empfängt die genannte lokale Positionierungsanzeige;
eine Signaldifferenzierungsschaltung empfängt die genannte lokale Positionierungsanzeige zur Differenzierung derselben mit dem Ziel der Bereitstellung einer differenzierten lokalen Positionierungsanzeige;
ein Signalpolaritätsumkehrmittel, das die Differenzierungsschaltung elektrisch mit der genannten Summiererschaltung verbindet, um die differenzierte lokale Positionierungsanzeige zu einem Eingang der Summiererschaltung zu übertragen;
das Referenzpotentialmittel ist mit dem zweiten Eingang an die genannte analoge Summiererschaltung verbunden und liefert ein Halteverriegelungsreferenzsignal an die genannte Summiererschaltung, um das Arbeitsobjekt in einem Halteverriegelungszustand über einem der genannten Indizien zu halten;
ein Spurbewegungssteuermittel zur Bereitstellung eines Positionierungsservosteuerungssignals an den genannten analogen Summierer,

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um das Positionsreferenzsignal zu ersetzen, wenn die Positionierungsservoschaltung das Arbeitsobjekt innerhalb der vorbestimmten Anzahl an Indizien bewegt; und
wobei das genannte Befehlsmittel weiterhin eine Verbindung zur genannten Positionierungsservoschaltung umfaßt, um das genannte Spurbewegungssteuerungsmittel und das genannte Polaritätsumkehrmittel zu betätigen, wenn die Steuerung von der Geschwindigkeitsservoschaltung zur Positionierungsservoschaltung umgeschaltet wird, um eine gleichzeitige Umkehr der Polarität des differenzierten lokalen Positionierungssignals bezüglich der Indizienkreuzungen zu erzielen, um ein kleines Fehlersignal als das genannte Servoantriebssignal von der Positionierungsservoschaltung zum Stellglied während der Ausführung der Steuerfunktionen der Positionierungsservoschaltung aufrechtzuerhalten.

6. Ein Positionierungsservosystem gemäß Anspruch 1 oder 5, bei dem das genannte Positionierungsfehlermittel folgendes umfaßt:
einen Abwärtszähler mit Zählinhalten, die für eine Anzahl von zu überquerenden Indizien repräsentativ sind, die überquert werden müssen, um eines der genannten Zielindizien zu erreichen, das operativ mit dem Arbeitsobjekt verbunden ist, um die genannte lokale Positionierungsanzeige zu empfangen, die auf die genannte lokale Positionierungsanzeige zur Abwärtszählung reagiert, während das Arbeitsobjekt die Indizien überquert, um zu einem der genannten Zielindizien zu gelangen, und eine Zählung erzeugt, die den Positionsfehler des Arbeitsobjekts bezüglich des Zielindizes angibt.

7. Ein Positionierungsservosystem gemäß Anspruch 1, des weiteren folgendes umfassend:
die genannte Positionierungsservoschaltung, die folgendes umfaßt:
ein Steuermittel zur Steuerung der Operation der Positionierungsservoschaltung, um die Positionierungsservoschaltung dazu zu veranlassen, das Arbeitsobjekt weg von einem aktuellen Indiz zu bewegen, indem ein Rampensignal bereitgestellt wird, das an einem Referenzpotential beginnt, das einen Halteverriegelungszustand über einem derzeit positioniertem Indiz darstellt, und dessen Amplitude, die einen Abstand zwischen einem derzeitigen Indiz und einem Zielindiz wiedergibt, steigt, und zum Zurücksetzen der Rampe auf ein Referenzpotential bei Erreichen des Zielindizes, und das weiterhin ein Mittel zur Bereitstellung eines Rampensignals daraufhin umfaßt, daß das Schaltmittel an einer maximalen Amplitude beginnt und auf das genannte Referenzpotential abfällt.

8. Ein Positionierungsservosystem gemäß Anspruch 1, des weiteren folgendes umfassend:
eine Datenaufzeichnungsvorrichtung, die das genannte Servosystem einschließt und mit einem beweglichen Wandler als dem genannten Arbeitsobjekt und einem Aufzeichnungsmedium als dem genannten Arbeitselement versehen ist; und
eine Mehrzahl voneinander getrennter Aufzeichnungsspuren auf dem Aufzeichnungsmedium, wobei jede Spur eines der genannten Positionsindizien ist.

9. Ein Positionierungsservosystem gemäß Anspruch 1 oder 8, das weiterhin in der Aufzeichnungsvorrichtung einen Rahmen umfaßt;
wobei das genannte Aufzeichnungsmedium eine Platte ist, die rotierbar am Rahmen angebracht ist;
wobei die genannte Halterung ein Kopfträger ist, der beweglich am Rahmen befestigt ist, und zu hin- und herlaufenden Bewegungen entlang eines Radius der genannten Platte dient;
wobei das genannte Stellglied und der genannte Wandler am genannten Kopfträger angebracht sind, wobei der Wandler am Kopfträger angebracht ist, um radiale Bewegungen bezüglich der Platte auszuführen; und
ein Mittel zur radialen Bewegung des Kopfträgers bezüglich der Platte und ein Mittel zur relativen Steuerung des Stellglieds und des Bewegungsmittels für den Träger, so daß der Wandler und der Träger gleichzeitig in bezug auf die Platte bewegt werden können.

10. Ein Positionierungsservosystem gemäß Anspruch 9, des weiteren folgendes umfassend:
eine grobe Servoschaltung, die an das genannte Bewegungsmittel zur Steuerung von Bewegungen des Kopfträgers angeschlossen ist;
ein Sensor auf dem Kopfträger zur Messung der relativen Position, der operativ am Wandler angeschlossen ist und die relative Position des Wandlers in bezug auf den Kopfträger anzeigt;
wobei die genannte grobe Servoschaltung an den Sensor zur Messung der relativen Position angeschlossen ist und von diesem Sensor ein Signal zur Aktivierung des Bewegungsmittels empfängt, mit dem der Kopfträger bewegt wird, um den Wandler in eine Referenzposition auf dem Kopfträger zu bringen; und
eine elektrische Verbindung zwischen dem genannten Stellglied und der genannten groben Servoschaltung zur Einstellung der Operation der groben Servoschaltung für Zufuhrsignale vom genannten Stellglied zur groben Servoschaltung zur schnelleren Bewegung des Kopfträgers, wenn der Sensor zur Messung der rela-

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tiven Position einen größeren als den vorbestimmten relativen Versatz zwischen einem Wandler und einem Kopfträger anzeigt.

11. Ein Verfahren zur Positionierung eines Arbeitsobjekts entlang eines Pfads auf einem Arbeitselement, bei dem der Pfad eine Mehrzahl empfindlicher, voneinander getrennter Positionsmarkierungen umfaßt;
folgende Schritte umfassend:
Erkennung der relativen Position des genannten Arbeitsobjekts entlang des genannten Pfads;
Relative Bewegung des Arbeitsobjekts entlang des genannten Pfads von der genannten erkannten relativen Position zu einer relativen Zielposition, so daß die erkannten relativen Zielpositionen entlang des genannten Pfads durch eine erste Mehrzahl der genannten Markierungen getrennt sind;
Steuerung der Bewegung entsprechend eines vorbestimmten Geschwindigkeitsprofils während eines ersten Teils der genannten relativen Bewegung;
Messung einer relativen Position innerhalb eines vorbestimmten Bereichs entlang des genannten Pfads, der von der genannten Zielmarkierung durch eine zweite Mehrzahl genannter Markierungen versetzt ist, wobei die genannte zweite Mehrzahl kleiner ist als die genannte erste Mehrzahl, jedoch größer ist als zwei;
Umschaltung vom genannten vorbestimmten Geschwindigkeitsprofil zu einem vorbestimmten Positionsfehlerprofil zum Abschluß der relativen Bewegung des Arbeitsobjekts entlang des genannten Pfads zur Zielmarkierung durch Überquerung der genannten zweiten Mehrzahl an Markierungen bei der Messung der genannten relativen Position; und
Halteverriegelung des Arbeitsobjekts und des Arbeitselements an der Zielmarkierung unter Verwendung eines vorbestimmten Positionsreferenzsignals.

12. Ein Verfahren gemäß Anspruch 11, weiterhin folgende Schritte umfassend:
Messung des genannten vorbestimmten Geschwindigkeitsprofils und des genannten vorbestimmten Positionierungsfehlerprofils im genannten Meßschritt; und, wenn die Profile eine identische Bewegung des Arbeitsobjekts anzeigen, Umschaltung im genannten Schaltschritt vom vorbestimmten Geschwindigkeitsprofil des Arbeitsobjekts entlang des genannten Pfads zum vorbestimmten Positionierungsfehlerprofil.

13. Ein Verfahren gemäß Anspruch 11, bei dem das Arbeitsobjekt an einem beweglichen Träger angebracht ist, wobei das Objekt bezüglich des beweglichen Trägers entlang des genannten Pfads relativ beweglich ist und der bewegliche Träger entlang des genannten Pfads ebenfalls beweglich ist;
weiterhin folgende Schritte umfassend:
Messung der relativen Position des Arbeitsobjekts bezüglich einer Referenzposition und bezüglich des beweglichen Trägers; und
kontinuierliche Bewegung des beweglichen Trägers mit dem Ziel, das Arbeitsobjekt so nahe wie möglich an die genannte Referenzposition am beweglichen Träger zu bewegen, einschließlich aller Bewegungen während der Verwendung entweder des Geschwindigkeitsfehlerprofils oder des Positionierungsfehlerprofils.

14. In einem Verfahren zur relativen Bewegung des ersten und des zweiten Objekts entlang eines vorbestimmten Pfads einer relativen Bewegung von einer ersten relativen Position zu einer zweiten relativen Position, die von der ersten relativen Position um einen vorbestimmten Abstand entfernt ist, Pfadpositionierungsanzeigemarkierungen am zweiten Objekt; folgende Schritte umfassend:
Bestimmung der Anzahl der genannten zu bewegenden Markierungen zur Erzielung einer vorbestimmten relativen Bewegung des genannten vorbestimmten Abstands;
wenn die genannte Zahl größer ist als eine erste Zahl, dann zunächst relative Bewegung der genannten Objekte gemäß eines vorbestimmten Geschwindigkeitsprofils, bis eine relative Position erreicht ist, die durch eine zweite Mehrzahl an Markierungen von der genannten zweiten relativen Position angezeigt wird, anschließend Änderung der Steuerung der Bewegung zu einem ersten vorbestimmten Positionierungssteuerprofil, das in einer Halteverriegelungssteuerung an der genannten zweiten relativen Position endet, wobei die genannte zweite Mehrzahl kleiner ist als die genannte erste Zahl, aber größer ist als zwei; und
wenn die genannte Zahl kleiner ist als die genannte erste Zahl, dann relative Bewegung der genannten Objekte unter Verwendung eines zweiten vorbestimmten Positionierungssteuerprofils einschließlich einer negativen Steigung bezüglich des genannten ersten vorbestimmten Positionierungssteuerprofils, und Abschluß an der genannten Halteverriegelungssteuerung.

Revendications

1. Système d'asservissement de position comportant un dispositif d'actionnement (46) monté de façon mobile sur un support et portant un objet en

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cours de travail (45) à positionner sur un trajet prédéterminé par rapport à un élément de travail (30) et étant disposé en relation opérationnelle par rapport à l'élément de travail (30), l'élément de travail (30) comportant une pluralité d'indices indicateurs de position espacés le long dudit trajet prédéterminé et étant sensibles à l'objet en cours de travail de telle sorte que l'objet en cours de travail (45) applique une indication de position locale de la relation de position entre l'objet en cours de travail (45) et tout indice généralement à détecter, un moyen d'erreur de position (79) étant connecté de manière opérationnelle à l'objet en cours de travail (45) pour recevoir ladite indication et pour appliquer un signal d'erreur de position indicateur d'une position de l'objet en cours de travail par rapport à un indice cible, le système comprenant un circuit d'asservissement de vitesse (106) connecté de manière opérationnelle au moyen d'erreur de position et au dispositif d'actionnement (46) pour commander l'actionnement afin de déplacer l'objet en cours de travail vers un indice cible; caractérisé par

un circuit d'asservissement de position (105) connecté de manière opérationnelle audit moyen d'erreur (79) et au dispositif d'actionnement (46) pour commander le dispositif d'actionnement (46) afin de maintenir ledit objet en cours de travail (45) dans une relation prédéterminée par rapport à un indice couramment à détecter par l'objet en cours de travail (45) et lors de la commande pour déplacer l'objet en cours de travail (45) le long dudit trajet prédéterminé vers un premier indice cible à l'intérieur d'un nombre prédéterminé d'indices à partir de l'indice en cours;

le circuit d'asservissement de vitesse (106) étant connecté de manière opérationnelle au moyen d'erreur de position et au dispositif d'actionnement (46) pour commander le dispositif d'actionnement (46) pour déplacer l'objet en cours de travail (45) d'un certain nombre d'indices depuis l'indice courant supérieur audit nombre prédéterminé d'indices le long dudit trajet prédéterminé vers un second indice cible; et

un moyen de commutation (107) interposé de manière opérationnelle entre lesdits circuits d'asservissement et ledit dispositif d'actionnement (46) pour permettre au circuit d'asservissement de vitesse (106) de commander le dispositif d'actionnement (46) pour tous les mouvements de l'objet en cours de travail (45) sur des indices espacés dudit second indice cible plus dudit nombre prédéterminé d'indices le long du trajet prédéterminé et pour commuter la commande du dispositif d'actionnement (46) à partir du circuit d'asservissement de vitesse (106) vers le circuit (105) d'asservissement de position lorsque l'objet en cours de travail (45) n'est pas à plus dudit nombre prédéterminé d'indices dudit second indice cible.

2. Système d'asservissement de position selon la revendication 1, dans lequel

lesdits circuits d'asservissement de position et de vitesse appliquent respectivement des signaux de commande asservie au dispositif d'actionnement pour le commander; et

ledit moyen de commutation, incluant un moyen de comparaison de signaux couplés de manière opérationnelle auxdits circuits d'asservissement de position et de vitesse pour recevoir séparément les signaux respectifs de commande d'asservissement et pour comparer les amplitudes desdits signaux de commande d'asservissement, lorsque les amplitudes atteignent une relation d'amplitude prédéterminée, puis ledit moyen de comparaison actionne la commande de commutation du moyen de commutation à partir du circuit d'asservissement de vitesse poru positionner le circuit d'asservissement si l'objet en cours de travail (45) n'est pas à plus dudit nombre prédéterminé d'indices dudit indice prédéterminé.

3. Système d'asservissement de position selon la revendication 2, dans lequel ledit moyen de commutation comporte en outre un moyen de proximité couplé de manière opérationnelle audit moyen d'erreur de position pour recevoir ledit signal d'erreur de position et étant sensible à celui-ci pour indiquer que la position relative de l'objet en cours de travail (45) par rapport audit second indice cible approche dudit nombre prédéterminé d'indices à partir dudit second indice cible et pour actionner ledit moyen de comparaison afin de commencer à comparer lesdits signaux de commande d'asservissement; et

ledit moyen de comparaison comporte des moyens d'inhibition pour empêcher la comparaison des signaux de commande d'asservissement jusqu'à ce que ledit moyen de proximité actionne ledit moyen de comparaison.

4. Système d'asservissement de position selon l'une quelconque des revendications précédentes comportant en outre

un moyen de commande couplé audit moyen de commutation pour appliquer une commande de recherche à celui-ci et auxdits circuits d'asservissement de position et de vitesse pour appliquer une direction et un certain nombre d'indices à traverser pour atteindre l'un desdits indices cibles; et

un moyen de sélection de mode dans le moyen de commande sensible à un certain nombre d'indices à traverser durant une recherche in-

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férieur audit nombre prédéterminé d'actionnement du moyen de commutation pour connecter le circuit d'asservissement de position au dispositif d'actionnement et déconnecter le circuit d'asservissement de vitesse du dispositif d'actionnement, et étant en outre sensible au nombre d'indices à traverser supérieur audit nombre prédéterminé d'indices pour actionner le moyen de commutation afin de connecter initialement le circuit d'asservissement de vitesse au dispositif d'actionnement et permettre au moyen de commutation de commuter la commande du circuit d'asservissement de position à partir du circuit d'asservissement de vitesse lorsque l'objet en cours de travail n'est pas à plus dudit nombre prédéterminé d'indices dudit indice cible.

5. Système d'asservissement de position selon la revendication 1, dans lequel en outre

ledit circuit d'asservissement de position comporte:

un circuit additionneur de signaux analogiques pour appliquer un signal de commande d'asservissement pour commander le dispositif d'actionnement et ayant des première et seconde entrées;

le circuit d'asservissement de position étant connecté audit objet en cours de travail pour recevoir ladite indication de position locale;

un circuit différentiateur de signaux recevant ladite indication de position locale pour la différentier afin d'appliquer une indication de position locale différentiée;

un moyen d'inversion de la polarité de signaux reliant électriquement le circuit de différentiation audit circuit additionneur pour transférer l'indication de position locale différentiée à une entrée du circuit additionneur;

un moyen de potentiel de référence connecté à la seconde entrée dudit circuit additionneur logique pour appliquer un signal de référence de verrouillage d'arrêt audit circuit additionneur pour maintenir l'objet en cours de travail dans une condition de verrouillage d'arrêt sur l'un desdits indices;

un moyen de commande de mouvement de piste pour appliquer un signal de commande d'asservissement de position audit additionneur analogique afin de remplacer le signal de référence de position lorsque le circuit d'asservissement de position déplace l'objet en cours de travail à l'intérieur dudit nombre prédéterminé d'indices; et

ledit moyen de commande comporte en outre une connexion audit circuit d'asservissement de position pour actionner ledit moyen de commande de mouvement de piste et ledit moyen d'inversion de polarité lors de la commande de commutation du dispositif d'actionnement à partir du circuit d'asservissement de vitesse vers le circuit d'asservissement de position pour inverser de manière synchrone la polarité du signal de position locale différentié par rapport aux croisements d'indices afin de maintenir un petit signal d'erreur comme ledit signal de commande d'asservissement entre le circuit d'asservissement de position et le dispositif d'actionnement au cours des opérations de commande du circuit d'asservissement de position.

6. Système d'asservissement de position selon la revendication 1 ou 5, dans lequel ledit moyen d'erreur de position comporte:

un compteur décompteur ayant un contenu de comptes représentatif d'un nombre d'indices à traverser pour atteindre l'un desdits indices cibles connectés de manière opérationnelle à l'objet en cours de travail pour recevoir ladite indication de position locale sensible à ladite indication de position locale pour décompter lorsque l'objet en cours de travail passe sur les indices en se dirigeant vers l'un desdits indices cibles et générant un compte indiquant l'erreur de position de l'objet en cours de travail par rapport aux indices cibles.

7. Système d'asservissement de position selon la revendication 1, comportant en outre, en combinaison:

ledit circuit d'asservissement de position comportant:

un moyen de commande pour commander le fonctionnement du circuit d'asservissement de position, pour conduire le circuit d'asservissement de position à déplacer l'objet en cours de travail en s'éloignant d'un indice courant en appliquant un signal de rampe commençant à un potentiel de référence qui représente une condition de verrouillage d'arrêt sur un indice positionné de manière courante et augmentant l'amplitude représentative d'une distance entre l'indice courant et un indice cible et remettant la rampe à un potentiel de référence lors de l'atteinte de l'indice cible, et comportant en outre un moyen pour appliquer un signal de rampe en réponse au moyen de commutation commençant à une amplitude maximum et diminuant vers ledit potentiel de référence.

8. Système d'asservissement de position selon la revendication 1, comportant en outre, en combinaison:

un appareil d'enregistrement de données comportant ledit système d'asservissement et comportant un transducteur mobile en tant que ledit objet en cours de travail, un support d'enre-

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gistrement en tant qu'élément d'objet en cours de travail; et

une pluralité de pistes d'enregistrement espacées sur le support d'enregistrement, chaque piste étant l'un desdits indices de position.

9. Système d'asservissement de position selon la revendication 1 ou 8, comportant en outre

un cadre dans l'appareil d'enregistrement;

ledit support d'enregistrement étant un disque monté pour tourner sur le cadre;

ledit support étant un chariot de tête monté de manière à se déplacer sur le cadre pour des mouvements de va et vient le long d'un rayon du disque;

ledit dispositif d'actionnement et le transducteur étant montés sur ledit chariot de tête avec le transducteur monté sur le chariot de tête pour des mouvements radiaux par rapport au disque; et

un moyen pour déplacer radialement le chariot de tête par rapport au disque et un moyen pour commander de manière relative le dispositif d'actionnement et le moyen de déplacement pour le chariot, de telle sorte que le transducteur et le chariot puissent être déplacés simultanément par rapport au disque.

10. Système d'asservissement de position selon la revendication 9, comportant en outre

un circuit d'asservissement grossier connecté audit moyen de déplacement pour commander les déplacements du chariot de tête;

un détecteur de position relative sur le chariot de tête et connecté de manière opérationnelle au transducteur pour indiquer la position relative du transducteur par rapport au chariot de tête;

ledit asservissement grossier étant connecté au détecteur de position relative pour recevoir le signal en provenance de celui-ci afin d'actionner le moyen de déplacement pour déplacer le chariot de tête afin d'asservir le transducteur dans une position de référence sur le chariot de tête; et

une connexion électrique entre ledit dispositif d'actionnement et ledit circuit d'asservissement grossier pour régler le fonctionnement du circuit d'asservissement grossier pour l'application de signaux directs en provenance dudit dispositif d'actionnement au circuit d'asservissement grossier pour déplacer le chariot de tête plus rapidement lorsque le détecteur de position relative indique un déplacement supérieur à un déplacement relatif prédéterminé entre un transducteur et un chariot de tête.

11. Procédé de positionnement d'un objet en cours de travail le long d'un trajet sur un élément de travail dans lequel le trajet a une pluralité de marques d'emplacements espacés sensibles;

comportant les étapes suivantes:

détection de la position relative dudit objet en cours de travail le long dudit trajet;

déplacement relatif de l'objet en cours de travail le long dudit trajet depuis ladite position relative détectée vers une position relative cible de telle sorte que les positions relatives détectée et cible sont séparées le long dudit trajet par une première pluralité desdites marques;

au cours d'une première partie dudit mouvement relatif commandant le déplacement conformément à un profil de vitesse prédéterminé;

détection d'un emplacement relatif dans une plage prédéterminée le long dudit trajet déplacé par rapport à la marque cible par une seconde pluralité desdites marques, ladite seconde pluralité étant inférieure à ladite première pluralité mais supérieure à deux;

lors de la détection dudit emplacement relatif de la plage, commutation entre ledit profil de vitesse prédéterminé et un profil d'erreur de position prédéterminé pour mettre fin au déplacement relatif de l'objet en cours de travail le long dudit trajet vers la marque cible traversant ladite seconde pluralité de marques; et

arrêt du verrouillage de l'objet en cours de travail et de l'élément de travail à la marque cible en utilisant un signal de référence de position prédéterminée.

12. Procédé selon la revendication 11 comportant en outre les étapes suivantes:

au cours de ladite étape de détection à la fois dudit profil de vitesse prédéterminé et dudit profil d'erreur de position prédéterminée et lorsque les profils indiquent un déplacement identique de l'objet en cours de travail, alors dans ladite étape de commutation, commutation entre le profil de vitesse prédéterminé de l'objet en cours de travail le long dudit trajet, et le profil d'erreur de position prédéterminée.

13. Procédé selon la revendication 11, dans lequel l'objet en cours de travail est porté sur un chariot mobile, l'objet pouvant se déplacer d'une manière relative par rapport au chariot mobile le long dudit trajet et le chariot mobile pouvant se déplacer aussi le long dudit trajet;

comportant en outre les étapes suivantes:

détection de la position relative de l'objet en cours de travail par rapport à une position de référence par rapport au chariot mobile et

déplacement en continu du chariot mobile pour conduire l'objet en cours de travail à être

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plus près possible de ladite position de référence sur le chariot mobile, y compris tous déplacements tout en utilisant l'un ou l'autre des profils de vitesse ou d'erreur de position.

14. Dans un procédé de déplacement relatif d'un premier et d'un second objets le long d'un trajet prédéterminé de déplacement relatif entre une première position relative et une seconde position relative déplacé à partir la première position relative d'une distance prédéterminée, en passant par des marques indicatrices de position sur le second objet;

comportant les étapes suivantes:

détermination du nombre desdites marques à déplacer pour obtenir un déplacement relatif prédéterminé de ladite distance prédéterminée;

si ledit nombre est supérieur à un premier nombre, alors tout d'abord déplacement relatif desdits objets en fonction d'un profil de vitesse prédéterminé jusqu'à ce qu'une position relative indiquée par une seconde pluralité de marques à partir de ladite seconde position relative soit atteinte, puis changement de la commande du déplacement vers un premier profil de commande de positionnement prédéterminé qui se termine dans une commande à verrouillage d'arrêt dans ladite seconde position relative, ladite seconde pluralité étant inférieure audit premier nombre mais supérieure à deux; et

si ledit nombre est inférieur audit premier nombre, alors déplacement relatif desdits objets en utilisant un second profil de commande de positionnement prédéterminé incluant une pente négative par rapport audit premier profil de commande de positionnement prédéterminé et se terminant à ladite commande à verrouillage d'arrêt.