Feb. 13, 1962 H. F. WELSH ETAL 3,021,512

SELECTOR MECHANISMS

Filed April 27, 1956 3 Sheets-Sheet 1

FIG. 1A.

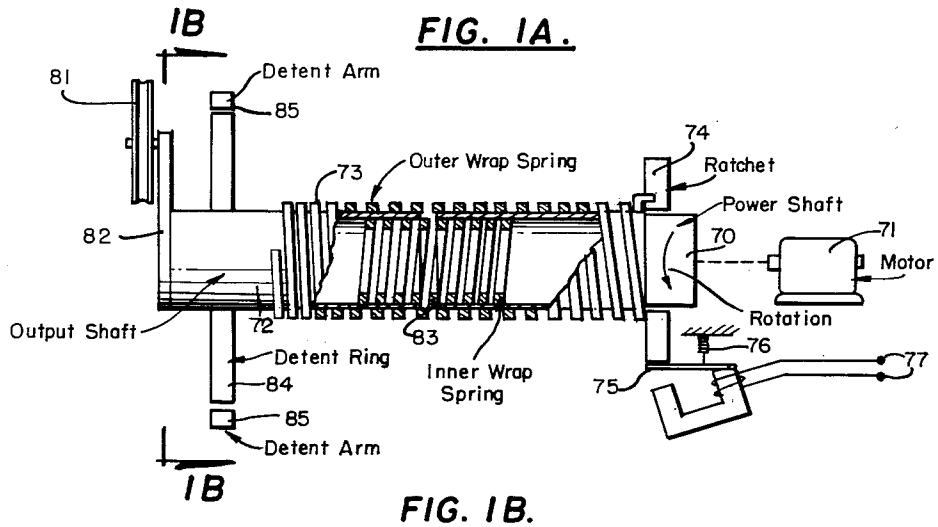


FIG. 1B.

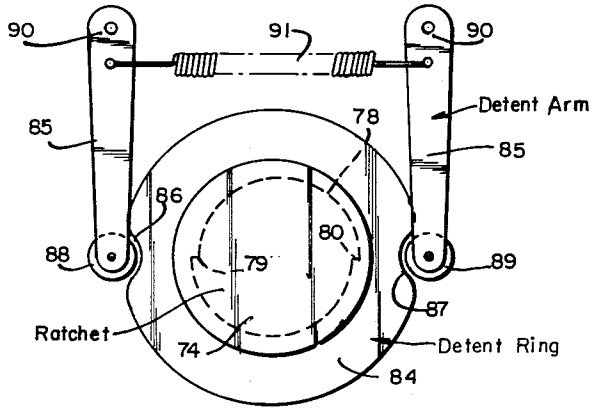


FIG. 1D.

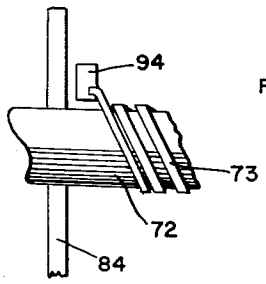
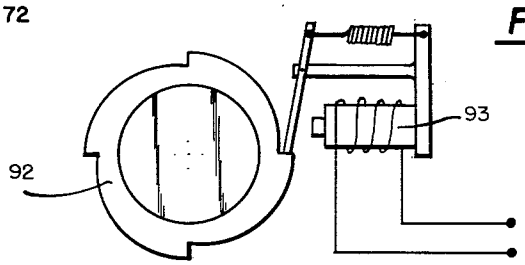


FIG. 1C.



INVENTORS
H. F. WELSH
N. J. APPLETON
M. SILVERBERG

BY Charles G. English
AGENT

Feb. 13, 1962 H. F. WELSH ETAL 3,021,512

SELECTOR MECHANISMS

Filed April 27, 1956 3 Sheets-Sheet 2

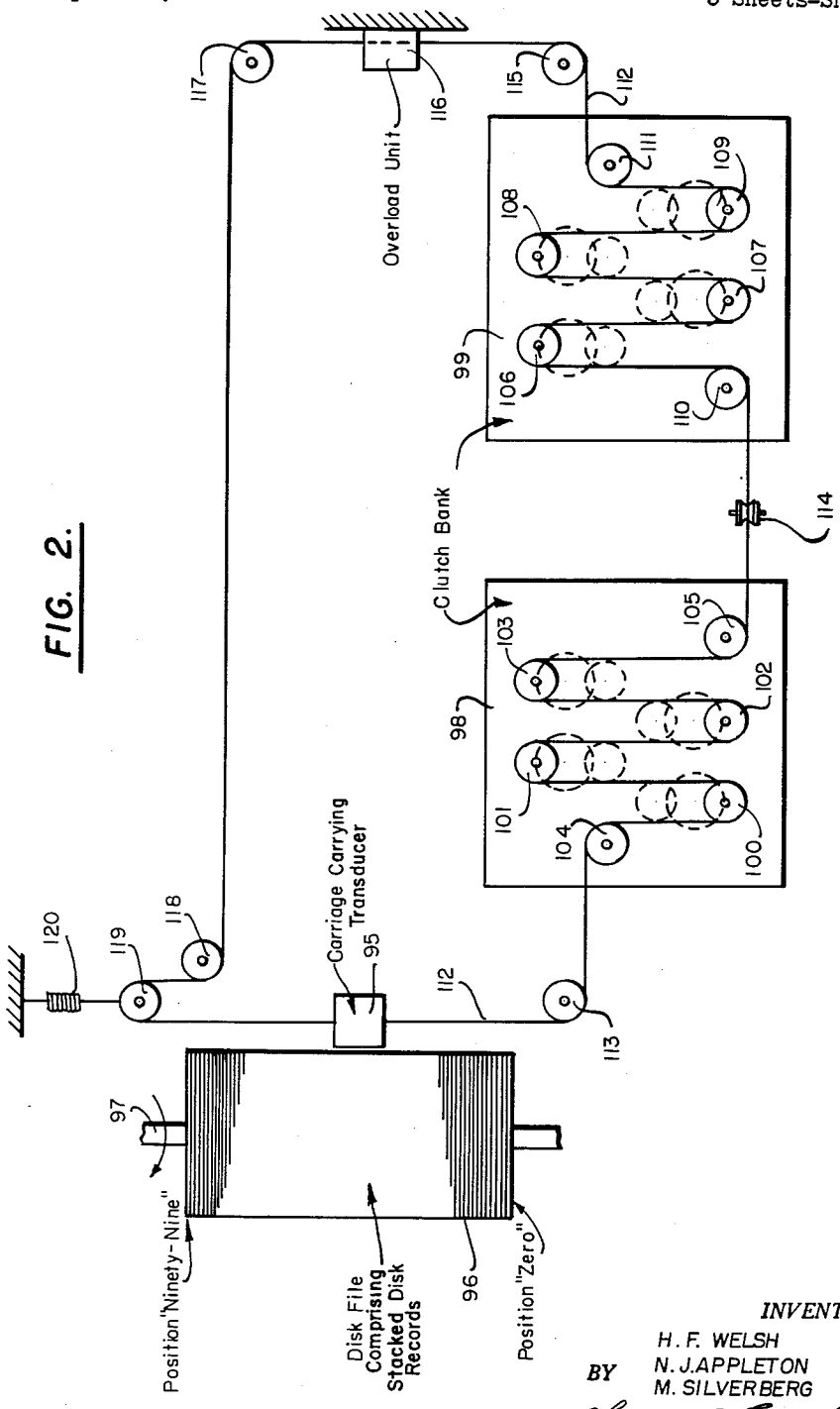


FIG. 2.

INVENTORS
H. F. WELSH
N. J. APPLETON
M. SILVERBERG

BY Charles G. English
AGENT

Feb. 13, 1962 H. F. WELSH ETAL 3,021,512

SELECTOR MECHANISMS

Filed April 27, 1956 3 Sheets-Sheet 3

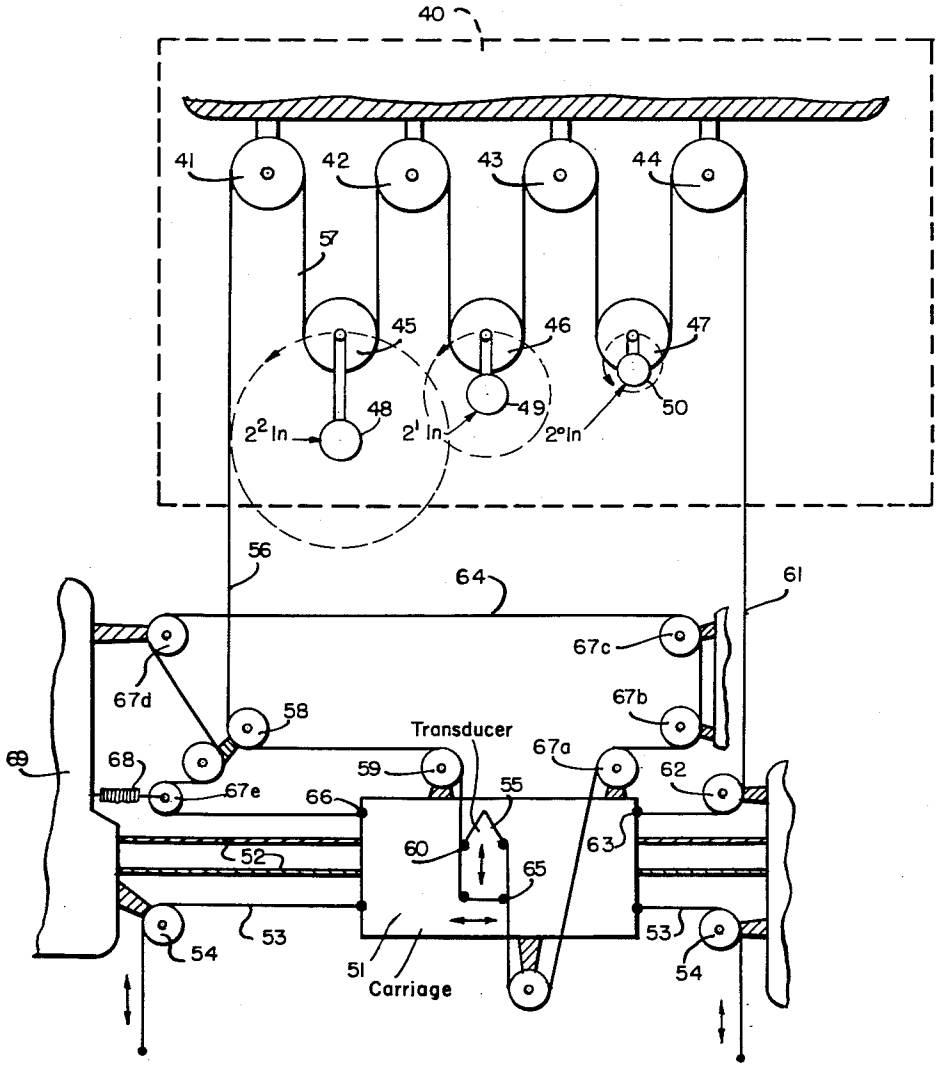


FIG. 3.

INVENTORS
H. F. WELSH
N. J. APPLETON
M. SILVERBERG

BY Charles C. English

AGENT

United States Patent Office 3,021,512 Patented Feb. 13, 1962

3,021,512

SELECTOR MECHANISMS

Herbert Frazer Welsh and Norman J. Appleton, Philadelphia, and Morton Silverberg, Elkins Park, Pa., assignors to Sperry Rand Corporation, New York, N.Y., a corporation of Delaware

Filed Apr. 27, 1956, Ser. No. 581,235
23 Claims. (Cl. 340—174.1)

The present invention relates to mechanisms for selectively positioning a work piece at one of a plurality of possible locations in response to coding signals; and is more particularly concerned with such selector mechanisms capable of utilization in digital computation systems, for instance as a portion of a disk-type magnetic memory.

It is often desired, in various mechanical structures, to position a work piece between any one of a number of stations. In the past, such positioning mechanisms have, for the most part, employed servo-mechanisms for moving the said work piece between individual stations, and feedback means have been employed in combination with such servo-mechanisms to signal when the work piece has arrived at the desired location so as to deenergize the servo-mechanism and to cause the work piece to come to a stop. Other types of mechanisms known in the art for selectively positioning work pieces have often comprised interposer devices whereby the work piece is merely moved toward a desired position and is then forcibly brought to a stop by the interposition of fixed stops serving to halt the work piece at the desired position.

Each of these known types of selector mechanism has been subject to the disadvantage that the resulting structure is relatively complex and costly in construction; or that in the alternative, the device is so massive in character that selection is relatively slow and imposes substantial physical strain upon the work piece, thereby raising the possibility of operating failures with the attendant cost of maintenance.

The present invention serves to obviate the foregoing difficulties and, in essence, provides mechanisms which, without inverse feedback techniques or stops, may directly position a work piece into any one of a plurality of digitally determined positions in response to a digital input code. The devices of the present invention find utility in digital computation devices wherein it is desired to physically position a work piece at one of a plurality of possible locations in response to a unique digital input code; and the work piece may comprise, for instance a magnetic transducer selectively positioned at one of a plurality of storage or pickup locations adjacent a magnetic storage surface. In this latter respect, reference is made, for instance, to the copending application of J. P. Eckert, et al., Serial No. 485,746, filed February 2, 1955, for "Reading Apparatus," which discloses a disk-type memory comprising a plurality of disk-like storage surfaces cooperating with writing and detection means for the selective storage and reading of information. The present application may be considered to provide possible selectors for the variable positioning of the writing and detection means with respect to such disk-like memory surfaces.

In accordance with the present invention, the foregoing selective positioning of a work piece may be effected by coupling the said work piece (e.g. a magnetic transducer) to an elongated cable, which cable in turn rides on a plurality of individually movable pulley devices and the said pulley devices may in turn be variably displaced in response to actuator means. By proper selection of the pulleys moved, as well as by appropriate preselection of the amount each pulley can move, the cable may be

selectively translated with respect to a plurality of stations (e.g. the magnetic records of a disk file) thereby to selectively move the aforesaid work piece to a predetermined one of these stations. A general system of this type is described in more detail, for instance, in U.S. Patent No. 1,139,972 to C. J. Henschel and C. Messick.

In accordance with one embodiment of the present invention, the cable employed may be fixed at at least one of its ends to a stationary reference structure whereby the work piece may be selectively translated in a single plane. In accordance with a further embodiment of the present invention, however, the cable may be affixed at at least one of its ends to a movable reference structure whereby the system comprises a differential selector mechanism capable of relative movement with respect to two orthogonal planes. This latter embodiment of the present invention finds particular utility in the disk-type memory discussed previously, wherein it is desired first to move with respect to the over-all memory thereby to preselect a particular memory disk for the reading or writing of information thereon, and it is thereafter desired to variably displace the reading or writing mechanism to one of a plurality of desired locations on the said selected disk. Each of the foregoing embodiments may, as will be described, employ various types of pulse or signal responsive actuators, and a preferred form of the invention utilizes selectively actuated wrap spring clutches of novel design.

It is accordingly an object of the present invention to provide novel and improved selector mechanisms.

A further object of the present invention resides in improved mechanisms adapted to selectively position a work piece in response to a digital input code.

Still another object of the present invention resides in the provision of novel selector mechanisms which need not employ feedback techniques or stop mechanisms for selectively positioning a work piece, such as a transducer, at one of a plurality of work stations.

A further object of the present invention resides in the provision of a differential selector mechanism wherein a work piece may be selectively moved in a first direction of operation without disturbing the position of the said work piece with respect to a moving work station; and wherein the work piece may be selectively positioned at one of a plurality of work stations in a second direction of operation in response to a predetermined electrical signal input.

Another object of the present invention resides in the provision of a novel memory system wherein a magnetic transducer may be selectively positioned with respect to a magnetic storage surface in response to a digital input signal.

A further object of the present invention resides in the provision of novel selector mechanisms which are simpler in construction and more rugged in configuration than those known heretofore.

A further object of the present invention resides in the provision of novel selector mechanisms capable of more rapid and more efficient operation than has been the case in the past.

Another object of the present invention resides in the provision of a novel selector mechanism employing a plurality of differently code-weighted wrap spring clutches for selectively positioning a work piece.

A still further object of the present invention resides in the provision of a novel transducer positioning device for use in a disk-file memory system.

Another object of the present invention resides in the provision of an improved random access memory system capable of more rapid utilization than has been the case heretofore.

The foregoing objects, advantages, construction and

operation of the present invention will become more readily apparent from the following description and accompanying drawings, in which:

FIGURE 1A illustrates an improved wrap spring clutch constructed in accordance with the present invention.

FIGURE 1B is a view taken on line B—B of FIGURE 1A.

FIGURE 1C illustrates an alternative ratchet and stop mechanism for a wrap spring clutch such as may be employed in the present invention.

FIGURE 1D illustrates a further portion of another alternative form of wrap spring clutch such as may be employed in the present invention.

FIGURE 2 is a diagram of a selector mechanism utilizing wrap spring clutches of the type illustrated in FIGURE 1A; and

FIGURE 3 is a diagrammatic representation of a differential selector mechanism constructed in accordance with the present invention.

In the devices of the prior art, many forms of actuating members have been used. One such actuating member is the solenoid, and this has been very popular in devices of the type described above. However, it has been found that in servo-positioning systems, a preferred actuator takes the form of 180° revolution clutches, and the elements to be moved, such as the above mentioned rotatable pulleys, are eccentrically mounted on an output shaft of such half-revolution clutches for moving the said pulleys to their said binary positions, thereby to alter the effective length of cable and the effective position of the work piece or transducer.

Before proceeding with the detailed discussion of the present invention, it should be not that a 180° clutch is one which, upon being pulsed with the proper signal, proceeds to rotate from one fixed position to another position 180° away. Attached fully rotating pulleys, eccentric to the axis of rotation of the clutch, will therefore displace through a distance equal to twice the eccentricity. The output motion imparted to the cable, due to each clutch, is basically sinusoidal; and if the clutches are started at the same time and have the same r.p.m., the full output is basically sinusoidal. This means that the output is started at maximum acceleration and zero velocity, is then brought up to maximum velocity and zero acceleration at a point near the center of the stroke; and is then brought to a stop with maximum acceleration and minimum velocity at the end of the stroke. The time of travel from any one position to any other is thus the same regardless of the distance moved.

Another important benefit deriving from the use of a clutch of the aforementioned type, is that the eccentric loading matches the impedance of the input power source and of the output. At the beginning and end of a cycle, when the forces are high (and the velocity is low) the pulley is near top dead-center giving the clutch a large mechanical advantage. At the mid-stroke (when the acceleration is near zero), the mechanical advantage is in favor of the cable. The design of the clutch accordingly becomes an important factor in the total mechanical selector unit and one type of clutch known as the wrap spring clutch is particularly suited for this type of service. A preferred form of such wrap spring clutch is illustrated in FIGURE 1A; and it will be noted from the subsequent description that some of the elements comprising this clutch differ from conventional wrap spring clutches.

Thus, referring to FIGURE 1A, it will be seen that in accordance with the present invention, an actuator taking the form of a wrap spring clutch may comprise a power shaft **70** which is constantly rotated by a motor **71**; and an output shaft **72** is disposed collinear with the power shaft **70** and spaced therefrom. An outer wrap spring **73** is placed about the power shaft **70** and output shaft **72**, and the turns of the said spring **73** are divided between the said output shaft and the power shaft. A ratchet **74** (the configuration of which is more easily seen in FIGURE 1B) is carried by the power shaft **70** and is adapted to be capable of free rotation on the said shaft **70**. Spring **73** is coupled at one of its ends to the said ratchet **74**, and is coupled at the other of its ends to output shaft **72**.

In the design of the clutch, the diameters of the power shaft **70** and output shaft **72** are the same, and the natural internal diameters of spring **73** is somewhat smaller than the diameters of the shafts **70** and **72**. A pulse-responsive interposer or latch **75** is coupled to the ratchet **74** and is held in position adjacent the said ratchet **74** by a spring **76** whereby, in the absence of pulse input at terminals **77**, the interposer **75** restrains rotation of the ratchet **74**. In this condition of operation, therefore, the outer wrap spring **73** is caused to exhibit a somewhat larger internal diameter than the diameters of shafts **70** and **72**; and no power is transferred through the spring **73** to the output shaft **72** from the constantly rotating power shaft **70**.

If now a pulse input should appear at terminals **77**, the interposer **75** will be pulled downward thereby releasing the ratchet **74**. The wrap spring **73** will thereupon engage the outer peripheries of power shaft **70** and output shaft **72**, and will drive the output shaft forward with a torque equal to

$$Pr^2w(e^{\mu\phi}-1)$$

where P is the interference pressure, r is the radius of the shafts **70** and **72**, w is the width of each wrap spring turn, e is the base of the natural system of logarithms, μ is the coefficient of friction, and ϕ is the number of turns of the wrap spring on the power shaft **70** in radians. The pulsed interposer **75** will thereafter ride upon the external peripheral surface of the ratchet **74**, as at **78** (see FIGURE 1B), until the said interposer **75** once more hits a step, such as **79**, in the ratchet **74**, whereupon the drive spring **73** will once more be disengaged and the output shaft will cease in its rotation.

Referring to FIGURE 1B for the moment, it will be seen that the steps **79** and **80** defined by the ratchet **74**, are substantially 180° with respect to one another, and therefore, when the wrap spring clutch, illustrated in FIGURE 1A, is pulsed, the output shaft **72** will define a 180° turn before it is once more caused to stop. During this rotation, a pulley **81** eccentrically coupled to the output shaft **72** by an arm **82**, will be caused to move through 180° and through a distance corresponding to twice the eccentricity afforded by arm **82**. When the pulley **81** does so move, a cable associated with that pulley will have its effective length changed in the manner described, for instance in the said patent to Henschel et al., whereby a work piece or transducer coupled to that cable will move through an appropriate distance.

In the particular form of wrap spring clutch shown in FIGURE 1A, a smaller or inner wrap spring **83** is disposed internal of the power shaft **70** and output shaft **72**, with the turns of the said spring **83** again being divided between the said shafts **70** and **72**. The direction of winding of spring **83** is opposite to that of drive spring **73**; and in practice, the spring **83** will slip so long as the power shaft **70** is turning faster than the output shaft **72**. If, however, the output shaft **72** should attempt to turn faster than the power shaft **70**, the inner spring **83** engages, thereby preventing the output from going faster than the chosen r.p.m. of the power shaft **70**.

The stopping torque for the wrap spring clutch, illustrated and described in reference to FIGURE 1A, is provided by a detent system comprising a detent ring **84** carried by the output shaft **82** and cooperating with a pair of detent arms **85**. This configuration will be more readily apparent from an examination of FIGURE 1B; and it will be seen that the detent ring **84** preferably includes one or more detent notches **86** and **87**, machined

into the said ring **84**. The detent notches **86** and **87** cooperate with a pair of roller followers **88** and **89** carried respectively by the pair of detent arms **85**; and the said detent arms **85** are pivotally mounted at points **90** and are spring-loaded by a spring **91**, whereby the roller followers **88** and **89** are urged toward one another into the detent notches **86** and **87**. When the drive clutch spring **73** (FIGURE 1A) is engaged by pulsing of the actuator interposer **75**, sufficient torque is developed to both accelerate the clutch and to drive it out of its detent position. The output shaft **72** then proceeds to rotate at some specified r.p.m. defined by motor **71**, through substantially 180°, in the manner already described; and as this rotation approaches its 180° position, the detent rollers **88** and **89** start to descend the detent notch walls defined by notches **86** and **87**. The inner wrap spring **83** does not allow any over-speed of the output shaft **72**, and the phasing of the rachet notches **79** and **80** with respect to the detent notches **86** and **87** is such that the interposer **75** contacts its appropriate step in the ratchet **74** at a time slightly before the detent rollers **88** and **89** reach the bottom of their corresponding detent notches.

If the energy product of the depth of the detent notch and the spring load afforded by spring **91** is greater than the energy contained in the rotation of the clutch, the clutch cannot go past its detent position, and is thus trapped. It is of interest to note that since the free end of the drive spring (that is the end of the spring attached to ratchet **74**) is prevented from rotating from a point prior to the zero position of the detent notch, the spring **73** is unwrapped from the shafts **70** and **72** in a static position, and this consideration serves to minimize the wear on the wrap spring **73**.

When it is desired to operate a clutch for a shorter cycle time than that already described, and when the stroke of the clutch need not be large, it is possible to operate the clutch through less than 180° in response to a pulse input. The ratchet **74**, described in reference to FIGURE 1A, may accordingly be replaced by a ratchet such as **92**, shown in FIGURE 1C. This particular ratchet includes four steps (rather than the two steps of ratchet **74**), said four steps being equiangularly spaced from one another and cooperating with a pulse responsive interposer, generically illustrated at **93**. By reason of this configuration, therefore, the application of a control pulse to the pulse responsive interposer **93** permits the clutch to operate through only 90 degrees (rather than through 180 degrees) whereafter clutch rotation is halted, until occurrence of a further control pulse, by the unwrapping of spring **73** as well as by a detent system similar to that already described in reference to FIGURES 1A and 1B. It should be noted, of course, that when the four-step ratchet **92** is employed, the detent ring (similar to **84**) should also have four, rather than two, spaced detent notches (similar to **86** and **87**).

While the form of wrap spring clutch described in reference to FIGURE 1A has one end of the spring **83** connected to the output shaft **72**, it should be noted that this is not necessary; and if desired, the said one end of spring **73** may be coupled to a mass **94** (see FIGURE 1D), rather than to the shaft **72** itself. This alternative configuration achieves certain appreciable benefits. Thus, the important adjustment in respect to the relationship between the down slope of the detent notch and the detent roller at the moment when the set or step in the ratchet strikes the interposer, such as **75**, is now done automatically and continuously.

If the interposer should strike its appropriate ratchet step before the detent roller has reached the detent notch, the spring **73** will stand still as the output comes to a stop. Each time the clutch is pulsed, the leading condition of the wrap spring is decreased until the roller falls into the detent shortly after the release of the drive spring. It should further be noted that, if for some reason such as wear, slippage, or initial adjustment, the opposite condition exists, i.e. the bottom of the detent notch leads the step of the ratchet, the action of mass **94** rectifies this error over a series of cycles; and each time the clutch stops, the mass **94** causes the spring **73** to unwind and shift forward a small amount. Over a series of operational cycles, therefore, the detent roller walks its way down the up-slope of the detents and the two actions then stabilize one another.

Wrap spring clutch actuators, generally of the type described in reference to FIGURES 1A, 1B, 1C and 1D find particular utility in pulley and cable type selector mechanisms, and a preferred form of selector mechanism utilizing such clutches is illustrated in FIGURE 2. Before proceeding with a detailed description of this selector system, however, it should be noted that in a preferred form of the invention, of the type illustrated in FIGURE 2, the actuator tends to move a carriage **95** adjacent an information storage system comprising a magnetic disk-file **96** which is rotated by shaft means **97**. A basic file, as presently utilized, comprises one hundred metal recording or storage disks of approximately 18 inches in diameter, stacked on a single shaft with a spacing between adjacent disks of approximately ¼ of an inch. The overall stack of magnetic storage disks thus has a height of 25 inches.

It has been shown that for a given frequency and a maximum pulse density, the most efficient storage can be accomplished on any one of the disks comprising the storage file **96** by using only one-half the diameter of a disk for writing and four and one-half inches of disk radius are accordingly available for this storage and reproduction of information. If we should now assume that the carriage **95** carries a transducer having five channels with a channel spacing of 25 to the inch, then one hundred channels occupy a distance of four inches. This means that the transducer or magnetic head carried by carriage **95** has to move to twenty distinct positions on each disk comprising the file **96**, in order to have access to all the information on that disk; and in order to simplify head construction, an interlacing scheme is ordinarily employed.

As described in the aforementioned application Serial No. 485,746, both surfaces of individual disks comprising the file **96** are employed for the reading and writing of information; and the magnetic heads, of which there are two carried by carriage **95**, are inserted into the space between two adjacent disks, with one head being positioned against the bottom surface of an upper disk, and the other head being positioned adjacent the top surface of a lower disk. The disks, as mentioned previously, are rotated by a shaft **97** at 1200 r.p.m. so that the repetition time for any information item on a given disk is 15 milliseconds.

The selector mechanism shown in FIGURE 2 cooperates with a disk file, generally of the type described above, for preselecting disks to be operated upon, and this selector comprises a clutch bank **98—99**. For purposes of clarity, the said bank **98—99** has been illustrated as two distinct clutch banks, each of which carries four half-revolution clutches and a pair of fixed pulleys. In a practical embodiment of the present invention, clutch bank **99** in fact comprises the opposite side of clutch bank **98**; and a total of four power shafts, extending completely through the banks **98—99**, are utilized to drive the eight half-revolution clutches coupled to opposing sides of the said bank **98—99**, respectively.

Referring to FIGURE 2 in greater detail, it will be seen that one side of the clutch bank designated as **98**, carries four half-revolution clutches **100** through **103** inclusive, and a pair of fixed pulleys **104** and **105**. Similarly, the other side of the clutch bank, designated as **99**, carries four further half-revolution clutches **106** through **109** inclusive, and a pair of fixed pulleys **110** and **111**. Possible alternative positions for the pulleys coupled to half-revolu-

tion clutches 100 to 103 and 106 through 109, are illustrated in dotted lines in FIGURE 2; but this particular dotted representation is not meant to be illustrative of the actual relative throws of the several clutches. To the contrary, and as will be described subsequently, the throws of the several clutches may either equal or differ from one another; and the use of clutches having different relative throws is specifically illustrated in FIGURE 3 (to be described), but has not been illustrated in FIGURE 2 due to the extremely wide ratio of throws (e.g. as much as 30 to 1) preferably employed in the arrangement of FIGURE 2. An elongated cable 112 is coupled to the aforementioned carriage 95 and is caused to pass adjacent a fixed pulley 113 into the several pulleys comprising clutch bank 98; and then passes over an end pulley 114 and over the several pulleys comprising clutch bank 99. The said cable 112 is then passed adjacent a further fixed pulley 115, through an overload unit 116 which serves to selectively protect the cable from excessive tensions produced by the system when the carriage 95 tends to be driven too far or otherwise cannot move when driven; and the said cable 112 then passes over further fixed pulleys 117 and 118 and over movable pulley 119, back to carriage 95. A spring or compliance member 120 is connected to the pulley 119 and thence to a stable structure, as illustrated, thereby to provide the desired compliance in the system.

In a preferred embodiment of the present invention, the code-weighting assigned to the several half-revolution clutches comprising the clutch banks 98—99, is such that the relative throws of the clutches (as determined, for instance, by the eccentric mounting of the pulleys thereon) are 30, 30, 20, 10, 3, 3, 2, and 1; and because of the continuity of the cable 112, the eight clutches having the aforementioned relative throws may be positioned as desired on the clutch bank 98—99. By utilizing eight clutches having the code-weighting designated, the selector mechanism is adapted to move carriage 95 through positions "zero" to "ninety-nine" (i.e. to any selected one of a hundred discrete positions) adjacent the disk file 96, in response to the pulsing of appropriate wrap spring clutches comprising the clutch bank 98—99. The function of these relative code-weightings will become more apparent from a consideration of the following.

As mentioned previously, the clutch bank 98—99 comprises a total of eight half-revolution clutches; and the individual clutches are, therefore binary devices having just two positions. The output end of each of the clutches carries an eccentric arm, on which is mounted a pulley on a bearing; and this structure has already been described in reference to FIGURE 1A. In addition, it will be noted that the clutches are arranged, as shown in the drawing, to cooperate with a cable, such as a thin steel cable 112, wound about their respective pulleys; and, as has already been discussed, it is evident that a change in position of any one clutch will result in either pulling in the cable or letting out the cable, by an amount equal to twice the total throw of a given clutch arm.

The aforementioned one hundred discrete positions of carriage 95 may be obtained by actuating a suitable combination of the eight clutches when the aforementioned code-weighting is assigned to these clutches respectively. Since the disks comprising file 96 are spaced one quarter of an inch apart, a one-unit clutch should have a throw of ⅛ of an inch; a two-unit clutch should have a throw of ¼ of an inch; a three-unit clutch should have a throw of ⅜ of an inch, etc. As mentioned previously, the eight clutches comprise a single one-unit clutch, a single two-unit clutch, two three-unit clutches, a single ten-unit clutch, a single twenty-unit clutch and two thirty-unit clutches; and due to the relative throws afforded by the clutches, the selective actuation of appropriate clutches will effect the aforementioned selective positioning of carriage 95 and of the heads carried thereby, through any one of one hundred discrete positions. Since the illustrated form of selector in FIGURE 2 is not a push-pull system, the compliance means or spring 120 is provided for providing acceleration in a direction opposite to that afforded by the selector. In other words, the spring 120 provides a pull in one direction while the clutch selector system provides a pull in the other direction.

Examining now the over-all structure shown in FIGURE 2, with reference to the discussion already given in reference to FIGURES 1A, 1B and 1C, it will be noted that the wrap spring clutch selector system is one giving a controlled acceleration. Each of the clutches basically contributes a modified sinusoidal acceleration to the carriage 95 and the summation of these accelerations, which are all of the same period, will be a modified sinusoidal acceleration having a maximum amplitude of about 14 G's (the 14 G figure being based upon the dimensioned clutch bank actually employed, and being also upon a 200 r.p.m. shaft speed). The clutches to be operated are all tripped simultaneously so that the output is a summation of the movements provided by individual clutches, and this means that full motion takes place in 150 milliseconds. The 14 G figure mentioned above is then required in moving the carriage the 25 inches comprising stack 96 in 150 milliseconds. While this figure may go up to 17 G's if the clutches are rotated in opposite directions, the important thing to note is that the acceleration is a controlled one and provides very rapid transportation of the carriage 95 with a minimum of acceleration. To do the same job in the same period of time using a squarewave acceleration, would reduce the acceleration figure by a little better than 30 percent; but such squarewave acceleration, while providing a theoretical optimum if jerk effects are not considered, is much more difficult to accomplish with a practical mechanism.

It should further be noted that the clutches employed are operated substantially as positive engagement clutches, and that it is only during the brief transition period when they are being accelerated up to speed that any slip occurs. During this period, however, the only load that the clutches see is their own inertia load, and this follows since at the instant of engagement their motion is at a right angle to the external load, i.e. to the cable tension, no matter how high that load is. Thus, the cable tension does not apply any torque load to the clutch during the instant of engagement, but acts directly through the center of the clutch bearing; and it is only after the clutch is actually engaged and moving from the vertical position that it starts to see the torque components of the external load.

It is also important to note that the wrap spring clutches, when driving the load, i.e. when pulling against the spring load as in the case of going from a position "zero" to a position "ninety-nine" adjacent disk file 96, accelerate the load for approximately half the distance, after which time the spring is serving to decelerate the load. The return spring 120 therefore has to be strong enough to insure the full deceleration of the load, and to maintain some necessary tension in the system at all times.

When the carriage 95 is going in the opposite direction, that is let us say from a position "ninety-nine" to a position "zero" adjacent disk file 96, the spring serves to accelerate the load while the clutch bank pays out cable. Now, since the clutches can only act in the opposite direction to the direction of the loads, this means that there is an overhauling load in this particular case, i.e. the spring 120 might tend to accelerate the output faster than the clutch is actually paying out cable. The clutch would then tend to override its drive shaft and would have an uncontrolled acceleration; but this operation is effectively prevented by the internal anti-overrunning wrap spring 83, described in reference to FIGURE 1A.

Thus, the design of the clutches is such that they again control the acceleration and deceleration in the reverse direction.

It should further be noted that due to the provision of the detent ring and detent arm and followers, described in reference to FIGURE 1B, the over-all system operates to position the carriage with substantially shockless deceleration, whereby noise, shock and wear in the system are substantially reduced.

While particular forms of selector mechanisms have been described, it should be stressed that the function of the selector is not to position the carriage or the heads carried thereby with extremely great accuracy, but serves to position the said carriage within relatively small limits, which may be further limited through the provision of a rack with fixed stops. Thus, the selector shown in FIGURE 2, for instance, will serve to position carriage **95** very rapidly, that is in 150 milliseconds, to an approximate desired position, for instance within one-half of the distance separating two adjacent disks comprising file **96**. The system may be so arranged that the carriage will over-shoot by approximately this one-half separation distance, and a latch can be thrown in the carriage whereby the said carriage latch may be lowered onto the rack stop.

It will be appreciated that the selector mechanism described in reference to FIGURE 2 moves a workpiece in a single direction with respect to a stationary reference structure. In practice, however, it is often desired to selectively position such a work piece within a moving system; and in this respect it is further desirable that the selector mechanism be substantially independent of the moving system. Thus, referring to the aforementioned copending application, Serial No. 485,746, the moving system may comprise a disk-type memory which may be selectively translated in a first plane thereby to preselect a particular storage surface for operation thereon. In such a disk-type memory system, the magnetic transducer operating on the disk memory is then required to be translated to a desired location on the preselected disk. It will be noted that the structure thus presented embodies movement in directions substantially orthogonal to one another; and in order to permit the work piece or transducer to be selectively positioned within such a moving system, a form of differential selector must be provided. One possible such arrangement has been illustrated in FIGURE 3.

Thus, a selector mechanism **40** may comprise a first plurality of stationary pulleys **41** through **44** inclusive and a second plurality of movable pulleys **45** through **47** inclusive, the said movable pulleys being selectively displaced by actuators **48** through **50** inclusive, under the control of signal inputs thereto. The selector mechanism **40** is thus identical in construction and operation with the selector of FIGURE 2, and it will be noted that the said selector mechanism **40** may be fixedly positioned within a selection device, and need not move. The over-all system may further comprise a movable structure **51**, corresponding for instance to the carriage **95** of FIGURE 2, and the said carriage **51** rides on tracks **52** and is capable of translation horizontally through the agency of a cable **53** coupled to fixed pulleys **54**. As has been mentioned previously, the moving system **51** or **95** may take the form of a carriage for a disk-type memory, and horizontal movement may be effected by a cable under the control, for instance, of a separate selector of the types described, for preselecting a particular disk to be operated upon, as is illustrated in FIGURE 2.

The selector mechanism **40** serves to position a work piece **55** (such as a magnetic transducer) at one of a plurality of locations in a direction substantially orthogonal to the direction of the system **51** or **95**. In this respect, therefore, one end **56** of cable **57** may be coupled via pulleys **58** and **59** to a point **60** on the work piece **55**; while the other end **61** of the cable **57** may be coupled via a pulley **62** to a point **63** on the movable system **51** or **95**. A further cable **64** may be coupled between a point **65** on the work piece **55** and a point **66** on the moving system **51** or **95**, via the several pulleys **67***a* through **67***e* inclusive. A compliance device **68**, which may comprise a spring, may be coupled between pulley **67***e* and a stationary reference structure **69**, as shown. It will be appreciated that the several pulleys **58**, **59**, **62**, and **67***a* through **67***e*, are provided for convenience only, and that other arrangements may be employed to accomplish the purposes of the present invention.

The differential selector system thus illustrated in FIGURE 3 comprises a movable work station and a work piece selectively capable of displacement at right angles to the direction of movement of the said station. The system further comprises a first cable network coupled to a selector mechanism wherein one end of the said first cable network is coupled to the movable system and the other end of the cable network is coupled to the work piece. A further cable network is also employed, coupled at one of its ends to the movable system and coupled at the other of its ends to the said work piece; and this further cable network may include the compliance means **68**, as shown.

Referring to FIGURE 3, it will be seen that motion of the moving system **51** or **95** will not affect the tension on cable **57** or the tension at the ends **56** and **61** of the said cable **57** inasmuch as cable **57** will merely run over idler pulleys **41** through **44**, **58**, **59** and **62**, and over the actuating pulleys **45** through **47**, during translation of the moving system **51** or **95**. Should it be desired, however, to alter the position of work piece **55**, within the moving system **51** or **95**, then selective actuation of the input lines to the selector mechanism **40** will cause relative motion of the individual selector pulleys **45**, **46** and **47**, thereby to cause a relative shortening or lengthening of the cables **57** and **64** so as to cause relative motion between the ends **56** and **61** of the said cable **57**. Such relative motion will move transducer or work piece **55** in the manner described, and this movement will operate against the compliance means **68** of the tensioning system composed of tension cable **64** and the pulleys associated therewith. Removal of signal inputs to the actuators **48** through **50** inclusive will similarly allow the work piece **55** to move in an opposite direction so as to relax the tensioning system comprising cable **64**, its associated pulleys and compliance means **68**.

It will thus be seen that signal inputs to the selector mechanism **40** will position the work piece **55** to one of a plurality of independent locations within the moving system **51** or **95**, and this positioning will be effected regardless of the arbitrary position of moving system; or regardless of whether the said system **51** or **95** is stationary or in motion. The device thus permits a relatively heavy, rugged and massive selector mechanism to be positioned externally of a moving system and to so operate on said moving system that members therein may be suitably adjusted or positioned. As a result, the actual portions of the system providing selection and relative or differential movement, are not affected by the mass of the selector mechanism itself, whereby high speed operation may be attained.

It should be noted that the tensioning system comprising cable **64**, pulleys **67***a* through **67***e* inclusive, and compliance means **68**, has been provided merely to relieve moving system **51** or **95** of the additional weight or mass of compliance means **68**. If this weight or mass factor is not important in operation of the overall system, the compliance means **68** may be incorporated directly into the said moving system and may comprise, for instance, a spring connected directly between points **65** and **66** whereby cable **64** and its associated pulleys may be eliminated.

While preferred embodiments of the present invention have been described, it will be appreciated that many variations will be suggested to those skilled in the art, in accordance with the principles discussed. The foregoing description is therefore meant to be illustrative only and is not limitative of our invention; and all such variations as are in accord with the principles described, are meant to fall within the scope of the appended claims.

Having thus described our invention, we claim:

1. In a positioning mechanism, a first movable body, means for moving said body in a first reference direction, a second movable body carried by said first body, selector means for moving said second body in a second reference direction substantially orthogonal to said first reference direction, said selector means comprising a cable coupled at one of its ends to said first body and coupled at the other of its ends to said second body so that motion of said first body in said first reference direction does not cause motion of said second body in said second reference direction, a plurality of non-displaceable idler pulleys adjacent said cable for establishing a reference location of said cable, and a plurality of signal responsive actuators coupled to said cable for selectively moving portions of said cable through predetermined displacements with respect to said idler pulleys to thereby move said second body in said second reference direction.

2. The positioning mechanism of claim 1 wherein each of said actuators includes a wrap spring clutch.

3. The positioning mechanism of claim 1 wherein each of said actuators includes a signal responsive partial revolution clutch, and a rotatable pulley eccentrically coupled to said clutch and in contact with said cable.

4. The mechanism of claim 1 wherein said plurality of actuators comprises a plurality of displaceable pulleys disposed intermediate said idler pulleys respectively, said cable being carried both by said displaceable pulleys and by said idler pulleys, and wrap spring clutch means coupled to said displaceable pulleys for selectively altering the positions of said displaceable pulleys with respect to the positions of said idler pulleys.

5. The mechanism of claim 4 wherein said wrap spring clutch means displace different ones of said displaceable pulleys through different physical distances, respectively, in response to signal inputs applied to said clutch means.

6. The mechanism of claim 1 including resilient means disposed between said first and second bodies for imposing a predetermined reference tension on said elongated cable.

7. The mechanism of claim 6 wherein said resilient means comprises a spring.

8. The mechanism of claim 6 wherein said resilient means comprises a further cable coupled at one of its ends to said first body and coupled at the other of its ends to said second body, a reference structure, and spring means disposed between said further cable and said reference structure.

9. The mechanism of claim 1 wherein said first movable body comprises a carriage movable with respect to an information storage device, said second movable body comprising an information transducer disposed on said carriage for movement adjacent said storage device.

10. A selector mechanism comprising an elongated cable, a first plurality of pulleys carrying said cable, a second plurality of pulleys carrying said cable, a plurality of signal responsive actuators for effecting predetermined relative displacements between pulleys of said first and second pluralities thereby to selectively change the positions of opposite ends of said elongated cable relative to one another, an information storage device, a carriage, transducer means carried by said cable and by said carriage adjacent said storage device, whereby the relative position between said storage device and said transducer means is varied in response to signals applied to said actuators, and means for selectively moving said carriage in a first reference direction, with respect to said storage device said selector mechanism moving said transducer means in a second reference direction substantially orthogonal to said first reference direction.

11. A selector mechanism comprising an elongated cable, a plurality of rotatable pulley devices carrying said cable, a work piece coupled to said cable, means for applying signals which indicate whether said work piece is to be moved, and a plurality of signal responsive wrap spring clutches eccentrically coupled to said pulley devices respectively such that said clutches rotate in accordance with signals applied thereto thereby to move said cable and said work piece as indicated by said signals.

12. The mechanism of claim 11 wherein each of said clutches comprises a power shaft and an output shaft, a spring adjacent both said power shaft and said output shaft, a ratchet, said spring being coupled at one of its ends to said ratchet, driving means coupled to said power shaft, and a signal responsive latch coupled to said ratchet, whereby said latch may be selectively actuated thereby to effect a power transfer from said driving means and power shaft to said output shaft via said spring.

13. The mechanism of claim 12 wherein each of said clutches includes a further spring adjacent both said power shaft and said output shaft, said further spring being adapted to engage said power shaft and output shaft only when the speed of rotation of said output shaft tends to exceed that of said power shaft, thereby to prevent overrunning of said output shaft.

14. The mechanism of claim 11 wherein each of said clutches includes a power shaft and an output shaft, and an arm attached to the longitudinal axis of said output shaft substantially orthogonal thereto, said pulley devices being coupled respectively to said arms at points spaced from the longitudinal axis of said output shaft.

15. The mechanism of claim 14 wherein different ones of said pulleys are differently spaced from their respective output shaft whereby said work piece is moved different distances in response to actuation of different ones of said clutches.

16. In a selector mechanism, a wrap spring clutch having a power shaft, an output shaft, and a spring for selectively coupling said power shaft to said output shaft, means for rotating said power shaft, pulse responsive means for causing said spring to transfer the rotation of said power shaft to said output shaft, a pulley connected to said output shaft with the pulley axis at a position displaced from the axial center of said output shaft whereby rotation of said output shaft changes the position of said pulley, a cable carried by said pulley, and a work piece connected to said cable whereby changes in position of said pulley are coupled through said cable to said work piece thereby to change the position of said work piece.

17. In an information storage system of the type having a plurality of rotatable recording disks arranged in series and adapted to be continuously rotated, and a transducer device movable in a first direction with respect to said disks to be positioned adjacent a selected one of said disks and movable in a second direction transverse to said first direction thereby to be positioned adjacent a certain portion of the selected disk, the combination therewith of a mechanism for positioning said transducer device, said mechanism comprising a carriage, first cable means connected to move said carriage in said first direction, first actuator means responsive to certain input signals for producing a certain displacement of said first cable means in said first direction, said transducer being supported on said carriage for movement in said second direction, second cable means connected to said transducer for producing movement of said transducer in said transverse direction with respect to said carriage, and second actuator means responsive to certain input signals for producing a certain displacement of said second cable means in said transverse direction, whereby said transducer may be moved in said two directions.

18. In an information storage system of the type having a plurality of rotatable recording disks arranged in series and adapted to be continuously rotated, and a transducer device movable in a first direction with respect to said disks to be positioned adjacent a selected one of said disks and movable in a second direction transversed to said first direction thereby to be positioned adjacent a certain portion of the selected disk, the combination therewith of a mechanism for positioning said transducer device, said mechanism comprising a carriage, first cable means connected to move said carriage in said first direction, first actuator means responsive to certain input signals for producing a certain displacement of said first cable means in said first direction, said transducer being supported on said carriage for movement in said second direction, second cable means connected to said transducer and to said carriage for producing movement of said transducer in said transverse direction with respect to said carriage and without regard to the position of said carriage, and second actuator means responsive to certain input signals for producing a certain displacement of said second cable means in said transverse direction.

19. In an information storage system of the type having a plurality of rotatable recording disks arranged in series and a transducer device movable in a first direction with respect to said disks to be positioned adjacent a selected one of said disks and movable in a second transverse direction to be positioned adjacent a certain portion of the selected disk, the combination therewith of a mechanism for positioning said transducer device, said mechanism comprising a carriage, first cable means connected to move said carriage in said first direction, first actuator means responsive to certain input signals for producing a certain displacement of said first cable means in said first direction, said transducer being supported on said carriage for movement in said second direction, second cable means connected to said transducer for producing movement of said transducer in said transverse direction with respect to said carriage, and second actuator means responsive to certain input signals for producing a certain displacement of said second cable means in said transverse direction, said first and second actuator means including different pluralities of pulleys mounted for swinging about eccentric axes for producing various displacements of said cables.

20. In a positioning mechanism, a first body movable with respect to a reference, a second body mounted for movement with said first body and with respect thereto, resilient means for yieldably biasing said second body toward a certain position with respect to said first body, a cable having one portion connected to said first body and another portion connected to said second body, means for guiding said cable for movement in a path having a predetermined relation to said reference, an actuator operable on a portion of said guiding means for selectively moving said cable thereby to move said second body from said certain position, whereby said second body can be selectively moved by said actuator to different positions with respect to said first body.

21. In a positioning mechanism, a first body movable with respect to a reference, a second body movable with respect to said reference and to said first body, means effecting relative motion both between each of said first and second movable bodies and between said second body and said reference, said motion effecting means comprising means for moving said first body with respect to said reference, a cable coupled at one of its ends to said first body and coupled at the other of its ends to said second body, and a plurality of actuators coupled to said cable, each of said actuators being responsive to a predetermined input signal for imposing a predetermined displacement of said cable with respect to said reference, each of said actuators thereby producing a displacement of said first body with respect to said second body of different magnitude without affecting the position of said first body with respect to said reference.

22. The mechanism of claim 21 wherein each of said actuators comprises a movable pulley device, and a signal responsive clutch eccentrically coupled to said pulley device.

23. The mechanism of claim 22 wherein each of said clutches comprises a half-revolution wrap spring clutch.

References Cited in the file of this patent

UNITED STATES PATENTS

843,508	White	Feb. 5, 1907
1,139,972	Henschel et al.	May 18, 1915
1,481,153	Rosendahl	Jan. 15, 1924
1,807,035	Herman	May 26, 1931
2,004,650	Collyear et al.	June 11, 1935
2,053,580	Racklyeft	Sept. 8, 1936
2,098,021	Wheeler	Nov. 2, 1937
2,161,941	Zapp	June 13, 1939
2,298,970	Russell	Oct. 13, 1942
2,301,908	Wilcox	Nov. 10, 1942
2,358,094	Panish	Sept. 12, 1944
2,411,055	Rich	Nov. 12, 1946
2,475,432	Marihart	July 5, 1949
2,511,349	Klay	June 13, 1950
2,519,725	White	Aug. 22, 1950
2,582,987	Hagenbook	Jan. 22, 1952
2,620,389	Potter	Dec. 2, 1952
2,674,728	Potter	Apr. 6, 1954
2,690,913	Rabinow	Oct. 5, 1954
2,733,425	Williams	Jan. 31, 1956
2,837,046	Carson et al.	June 3, 1958
2,847,859	Lynott	Aug. 19, 1958