MECHANICAL SHIFT REGISTER

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The invention relates to a mechanical shift register for serially reading out and/or visually displaying a value which has been generated previously in a computer or the like.

The register comprises a plurality of ordinarily arranged numeral wheels with an interordinal member being provided for each numeral wheel. The lowest ordinal numeral wheel is set in accordance with a predetermined, or sensed, ordinal value standing in the computer. The adjacent interordinal member is then set to a corresponding value under the control of the lowest order numeral wheel after which the second numeral wheel is set to this corresponding value under the control of the interordinal member. At the same time that the second numeral wheel is set to such value, the first ordinal numeral wheel is set to a new value corresponding to the second ordinal value sensed. This serial read-out process is repeated until a multi-order value has been transferred from the computer to the shift register.

The numeral wheels and interordinal members are mounted upon a common drive shaft and are frictionally engaged by the drive shaft. The numeral wheels and interordinal members are alternately locked and released in respective groups. Upon release, the numeral wheels are each frictionally driven to the extent permitted by the respective values standing in their adjacent interordinal members. Then the numeral wheels are locked and the interordinal members are released at which time the interordinal members are frictionally driven to the extent permitted by the values standing in their respective adjacent numeral wheels.

In the embodiment described, the values are serially entered from right to left; however, the values could as well be introduced in the reverse direction.

The means for entering the ordinal values, one by one, may be controlled either by a keyboard, or by another register. The invention is not directed to the specific manner in which values are entered into the first order, but is only concerned with the manner of transferring the successive ordinal values from one numeral wheel to the next. Therefore, an entry mechanism is provided which is shown in schematic form only for manually setting the lowest ordinal numeral wheel of the register in accordance with successive values which are to be displayed.

An object of the invention is to sequentially enter and ordinarily propagate values in a numeral wheel register.

Another object is to provide a shift register of this type which is simple in construction and precise in operation.

A further object of the invention is to provide a registering mechanism which will receive and propagate the successive character indications at a high rate of speed.

A further object of the invention is to provide a serial read-out registering mechanism which is unlimited as to the number of denominational orders contained therein.

Another object is to provide a combination of components which aligns and locks numeral wheels of a serial read-out register in positions of full digital display.

A further object is to eliminate the precession normal-
with the decimal selection made at dial 31. The projection 47 lies in the plane of rotation of a lug 51-1 carried by the first order numeral wheel 50-1.

The next consecutive higher order numeral wheel is numbered 50-2, the suffix "2" indicating that it is the second order numeral wheel. The interordinal member 60-1 is set under the control of the numeral wheel 50-1 and bears the same suffix of "1." Each numeral wheel and each interordinal member is fitted over an individual spring loaded ball 71 carried by drive shaft 15. Each spring-loaded ball 71 lies in a recess 73 drilled in the drive shaft. The inner circumference 58 of each numeral wheel 50 and the inner circumference 68 of each interordinal member 60 is thus continually engaged by a respective spring loaded ball 71 and in this manner is frictionally coupled to rotate in the direction of rotation of the drive shaft. The frictional coupling between the shaft 15 and each numeral wheel and each interordinal member is, however, easily broken by merely holding one or more of the components against rotation. The components may be held in this manner without impeding rotation of the drive shaft.

Each numeral wheel carries a contact lug 51 and a stop lug 52. Each interordinal member 60 carries a contact lug 61 and a stop lug 62. Projection 47 acts as a stop for the contact lug 51-1 of the numeral wheel 50-1. The stop lug 52-1 of numeral wheel 50-1 cooperates with the coplanar contact lug 61-1 on the interordinal member 60-1. In Fig. 2, the stop lug 52-1 is more clearly shown on the inner circumference of the first order numeral wheel 50-1. In this drawing the components are shown in assembled position and the contact lug 61-1 of the first interordinal member is shown in true relation to the stop lug 52-1. Also shown in Fig. 2 is the stop lug 62-1 of the interordinal member 60-1. Lug 62-1 cooperates with the coplanar contact lug 51-2 of the second highest order numeral wheel 50-2.

First the interordinal members are locked in their respective angular positions and the register numeral wheels are released and angularly advanced by the main drive shaft 15 until the contact lug 51 on each numeral wheel abuts a respective coplanar stop lug 62 of the adjacent lower interordinal member. Then the numeral wheels are locked and the interordinal members 60 are frictionally driven until their respective contact lugs 61 each abuts an angularly set stop lug 52 of the respective numeral wheel. In this manner a selected value is propagated from the lowest order through successive higher orders.

The locking cam shaft 13 is mounted for rotation directly below the drive shaft 15 and is rotated 360° during each clutch cycle, whereas the drive shaft 15 is rotated twice during each clutch cycle.

The locking cam shaft 13 carries two opposed banks of Geneva type cam lobes 80 and 82 along its length. Each cam lobe covers approximately 180° of the cam shaft circumference. During approximately half of a cam shaft revolution each numeral wheel 50 is locked against angular movement by a respective cam lobe 80 and during the second half revolution of shaft 13, the interordinal members are locked against angular rotation by respective cam lobes 82.

Each numeral wheel and interordinal member has ten distinct Geneva lock surfaces or concave depressions 54 and 64, respectively, spaced around its respective circumference. These depressions are engaged by the respective mating Geneva cam lobes 80 and 82 to lock the numeral wheel or member in one of ten possible angular positions. These positions, of course, correspond to the ten decimal digits as displayed by the shell of the numeral wheel.

The invention is not limited to the decimal system, but could as well be made to read out and display values in any base. The invention would read out such values by simply altering the components so that each had the number of depressions equal to the radix of the number system used. For example, eight depressions would be employed to read out octal values, and the manual input dial 31 would be correspondingly changed to contain only eight possible positions.

An additional advantage of the invention is that with any radix system selected, an additional place may be included as the radix point, and propagated in proper relationship with the digits of the value. For example in the embodiment shown an additional depression is formed on the components and the eleventh depression would indicate the decimal point. The dial 31 would be altered correspondingly and by selecting the decimal point at the dial, the point would be propagated in the selected relationship to the other decimal figures selected.

To further illustrate the invention, propagation of a two digit number will now be described. A selection of "3" is manually made at dial 31 which acts through the gears 41 and 43 to set the value selecting projection 47 at the angular position which is indicative of the value 3.

The value selecting projection 47 projects leftward into the plane of the contact lug 51-1 on the numeral wheel 50-1. Following such digital selection, the operation initiating key 19 is depressed, and the clutch 11 engaged for a single cycle.

In the initial position of the parts, the trailing ends of the cam lobes 80 are standing in locking relation with a portion of their mating cam surfaces 54 on the numeral wheels. Then when the clutch 11 is engaged, the numeral wheels are released from cam lobes 80 and the interordinal members are locked by cam lobes 82. The first numeral wheel 50-1 is driven until its contact lug 51-1 abuts the projection 47 and the numeral wheel is thereby set to the angular position indicative of the value 3. The cam lobes 82 thereafter release the interordinal members and lobes 80 engage all of the numeral wheels. This permits all interordinal members 60 to rotate to value representing positions determined by their adjacent numeral wheels. The cycle ends with the numeral wheels locked by lobes 80 in full display position with the "3" displayed in the first order.

A value of "7" is now selected at dial 31. The second cycle is initiated as before, by operation of key 19. In the first half of this second cycle the "3" selection is propagated to be displayed by the second order numeral wheel 50-2 and the "7" is placed in the first order numeral wheel 50-1.

During the first half of this second cycle the first order numeral wheel 50-1 advances until it abuts the projection 47 which now indicates the "7," and the numeral wheel 50-2 advances until its contact lug 51-2 abuts the stop lug 62-1 of the interordinal member which stands at a value of "3." Simultaneously, the interordinal number 60-2 is driven until its contact lug 61-2 abuts the stop lug 52-2 on the second highest numeral wheel 50-2 which stands at a value of "3." As the second cycle reaches completion the numeral wheels stand locked in their full display positions by respective cam lobes 80 and the decimal value "37" is displayed by the register. The operation may of course be repeated to enter succeeding digits.

It will be noted that if no new selection were made in this second cycle, i.e., if the decimal "37" were to remain as the selection in the second cycle, then the first order numeral wheel would be held against rotation by the existing contact of stop lug 51-1 with the projection 47.

That is, the projection 47 would remain in the selected demical "37" position and prevent the numeral wheel 50-1, from moving to a new selected position after release by its cam lobe 80. Therefore, the projection 47 is removed momentarily from the path of the stop lug 51-1 at the beginning of each operating cycle. For this purpose there is provided a cross arm 90 which contains the ends 92 (only one of which is shown). An upper extending arm 94 and a lower extending arm 96 are integrally with the cross arm 90. The lower arm 96 has a tip 98 which rides in a box cam slot 100 on the locking cam
shaft 13. The upper arm 94 rides in an appropriate circumferential slot 102 on the selector unit 45. The box cam 100 has a cam rise 104 which acts on the cam lock 98 at the proper period during rotation of the locking cam shaft 13 to shift the selector unit 45 rightward by rocking cross arm 90 clockwise in response to tip 98 riding up the cam rise. It will be noted that the cam rise is approaching the tip 98 in Fig. 1. Rotation of the locking cam shaft causes the selector unit 45 to be swiftly shifted to the right and then back to the left to temporarily remove the projection 47 from beneath the contact lug 51–1. This shifting movement of the selector unit 45 is so timed as to occur just as the numeral wheels of the register are released by their respective cam lobes 80. Therefore if the same digit is selected in successive cycles, the components always angularly move 360° to successively assume the same digital display position, thus permitting the first order numeral wheel to advance and subsequently permitting its adjacent interordinal member to advance to thereby properly propagate the numbers.

Due to manufacturing considerations, all of the numeral wheels are identical and all of the interordinal members are identical; thus it will be observed that due to the thickness of the respective contact and stop lugs, a contact lug will, upon abutment with its respective stop lug, lag behind the stop lug. Such lagging, or precession, would build up from order to order if means were not provided to prevent it. In the preferred embodiment disclosed such lagging is compensated for by permitting each numeral wheel or interordinal member to advance by an additional amount corresponding to the thickness of the stop lug. For this purpose there is a slight interval between the time that a cam lobe 80 releases its respective numeral wheel and the time that the cam lobe 82 contacts the interordinal member. Thus, the interordinal member follows the numeral wheel for a short interval to advance from its "lag" position to a full digital position before it is centralized by cam lobe 82. The cam lobes are also designed to similarly permit any numeral wheel to follow its interordinal wheel by the amount required to eliminate the above described lag.

The description of the invention has thus far been premised on manual introduction of digital values and single cyclic operation of clutch 11 by key 19. The mechanism is also adaptable to operate continuously and read out consecutive digital values from a computer of the like. To this end the clutch would be continuously operated for a number of consecutive cycles which would equal the number of digits or orders in the value to be read out.

The individual digits, it will be recalled, are each introduced during the cyclic interval when the numeral wheels are locked, therefore, during read-out operation, the individual digits would necessarily be introduced in descending denominational order, with the individual entries operable to adjust a device such as dial 31, and timed each cycle to occur while the numeral wheels are locked. In this manner, for example, a ten-order decimal value would be read out in ten continuous cycles of operation to a ten-order mechanical shift register.

Certain computer output devices require that the dial 31 or its equivalent be rotated from its previous setting to its new setting even though the same value is to be entered into the register. For example, if the dial 31 stands for a a value of "10", and the value of "10" is to be entered therein, the dial 31 is rotated 360° from its starting position back to its original position. For this purpose the projection 47 is pivoted mounted at 48 to permit the projection to move clockwise against the urgency of its spring 49 as the projection passes the contact lug 51–1 on the numeral wheel. This would occur slightly before 360° of rotation of the projection 47. It will be apparent to those skilled in the art that multi-order value stored in the numeral wheel register may be translated into a serially generated pulse train of representative electrical signals. This may be accomplished by repeatedly sensing the rotated position of the highest denominational order numeral wheel in the register. For example, in decimal operation, the highest order numeral wheel would have a switch-closing projection which cooperates with one of ten switches to generate a representative pulse each time the numeral wheel is moved to a new position. It is apparent that the highest order numeral wheel displaces successive decimal figures in the order of their immediate production. Therefore, the selected numeral wheel will operate the ten switches in correspondence to the successive entries and thereby generate on ten discrete lines the pulse train representative of the decimal value in the numeral wheel register.

The numeral wheel register is cleared by entering a succession of zeros into the register. The shift register may be used as a mechanically recirculating mechanism in the following manner. Assume that an interordinal member is located to the left of the highest order numeral wheel of the register and that means are provided for selectively connecting and disconnecting this highest order member with the selecting unit of the numeral wheel. Further, assume that means are provided for selectively connecting and disconnecting the manually selectable disc 31 from the selector unit 45. When the disc is disconnected and the highest ordinal member is connected to the member 45 and the clutch is continuously engaged, the value standing in the register will be continuously recirculated therethrough. Furthermore, assuming that the shift register is a ten-order register, then by effecting nine ordinal shifts through the recirculating mechanism, the value originally standing in the register will have been shifted one order to the right.

If the recirculated value is combined by means of a differential gear mechanism, with a value entered through the disc the shift register may be used as an accumulator.

The invention claimed is:

1. A shift register comprising a drive shaft rotatable in one direction, a plurality of ordinarily arranged numeral wheels frictionally mounted upon the drive shaft, means for adjusting a first numeral wheel to a discrete value representative position, respective detents for preventing rotation of the numeral wheels with the drive shaft, an interordinal member frictionally mounted on the drive shaft between each respective pair of numeral wheels, respective detents for rotation of the interordinal members with the drive shaft, a respective stop lug fixed on each numeral wheel and each interordinal member, a respective contact lug fixed on each numeral wheel and each interordinal member, control means operable first to disable the detents of the interordinal members while the numeral wheel detents hold the numeral wheels in fixed position to permit the interordinal members to rotate with the drive shaft to the extent permitted by contact of a contact lug on the member with a stop lug on its adjacent numeral wheel, and operable second to disable the detents of the numeral wheels while the interordinal member detents hold the members in fixed position, to permit the numeral wheels to rotate with the drive shaft to the extent permitted by contact of their respective contact lugs with the stop lugs of their adjacent lower order interordinal members.

2. A mechanical shift register comprising a plurality of ordinarily arranged numeral wheels frictionally mounted on a drive shaft, a respective contact lug and a stop lug, a plurality of interordinal storing wheels one being located between each adjacent pair of numeral wheels, a contact lug and a stop lug being provided on each storing wheel, means for rotating a first numeral wheel in a predetermined direction to a selected value representative position, the value being operable under control of the stop lug of said first numeral wheel and the contact lug of a respective storing wheel for rotating the storing wheel in the same direction to
the same value representative position in which the first numeral wheel stands, means subsequently operable under the control of the stop lug of the storing wheel and the contact lug of a second numeral wheel for rotating the second numeral wheel in the same direction to the same selected value representative position as the storing wheel, and means operable concurrently with the second numeral wheel for rotating means for rotating the first numeral wheel in the same direction to a second value representative position.

3. A mechanical shift register comprising a plurality of ordinarily arranged numeral wheels which are frictionally mounted on a shaft, a respective interordinal member frictionally mounted on the shaft between each adjacent pair of numeral wheels, means for alternately locking the numeral wheels and the interordinal members against movement with said shaft, a lug on a first numeral wheel operable during rotation of the numeral wheel to contact a selectively settable stop lug, a lug carried by the interordinal member operable upon rotation of said member to contact a stop lug carried by the first numeral wheel, a second numeral wheel having a lug for contacting a stop lug on the interordinal member, and means operable in timed relationship with said locking means to move the selectively settable stop lug out of the path of rotation of said first numeral wheel contact lug.

4. A reciprocating shift register comprising a plurality of ordinarily arranged numeral wheels with an interordinal member located adjacent each numeral wheel, adjustable means for controlling the rotation of a first numeral wheel to a discrete value representative position, mechanism operable under control of said numeral wheel for rotating the adjacent interordinal member to said discrete position, means operable under control of said interordinal member for rotating a second numeral wheel to said discrete position, mechanism operable under control of the second numeral wheel to rotate a second interordinal member to said discrete position, and means operable by said second interordinal member for adjusting said control means for the first numeral wheel.

5. In a shift register comprising a plurality of ordinarily arranged numeral wheels, an interordinal member for each adjacent pair of numeral wheels, means tending to rotate the numeral wheels and the interordinal members in a common direction, means for alternately locking and releasing the numeral wheels, means for alternately locking and releasing the interordinal members, means for setting a first numeral wheel in a discrete value representative position, a stop lug on said first numeral wheel and operable when the member is locked against rotation to contact a lug on the adjacent member and stop the rotation thereof, a stop lug on the member and operable when the numeral wheel is locked against rotation to contact a lug on a second numeral wheel and stop the rotation thereof, said stopping means for the numeral wheels being operable as a group while the interordinal members are released as a group and vice versa with an interval of time being provided between the unlocking of one group and the locking of the other group to provide a period of time during which both the numeral wheels and interordinal members are free to rotate.

6. A shift register comprising a plurality of N ordinarily arranged value registering devices, cyclically operable means for shifting the respective values standing in the register devices in order in a first direction for each cycle of operation, recirculating means connecting the endmost orders of the register and operable by said cyclically operable means to shift a value from one endmost order to the other endmost order, and mechanism for driving the cyclically operable means for X number of cycles less than N to effect N-X ordinal shifts in a second direction.

7. A mechanical shift register comprising a plurality of ordinarily arranged numeral wheels frictionally mounted upon a drive shaft, a respective interordinal storage member frictionally mounted on said shaft adjacent each numeral wheel and each numeral wheel having a stop lug located in the plane of rotation of a contact lug on a respective storage member, a stop lug on each storage member located in the plane of rotation of a contact lug on the respective adjacent ordinarily higher numeral wheel, a cam shaft substantially parallel to the drive shaft carrying a locking cam for each respective numeral wheel, and a locking cam for each respective interordinal member, a plurality of mating surfaces on the numeral wheels, and members for cooperation with their respective cans, said numeral wheel cans being diametrically opposed to said member cans, and all of said cans describing an arc less than 180° each when during each 180° rotation of the cam shaft the numeral wheels and interordinal members are unlocked to permit concurrent rotation thereof.

8. A shift register as defined in claim 7 including means for rotating the drive shaft at a speed which is at least twice the speed of rotation of the cam shaft.

9. A shift register as defined in claim 7 including a selectively settable stop lug for cooperation with the contact lug of an endmost numeral wheel on the drive shaft.

10. A shift register comprising a stop selectively settable to any one of ten discrete value representative positions, a first numeral wheel having a contact lug means resiliently urging the numeral wheel contact lug in a predetermined direction into engagement with the stop, means operable to lock the first numeral wheel in one of ten discrete positions, a stop lug in the numeral wheel, a storage member having a contact lug, means resiliently urging the contact lug of the storage member in said predetermined direction into engagement with the numeral wheel stop, means operable to lock the storage member in one of ten discrete positions, a stop on said member, a second numeral wheel having a contact lug and resiliently urged into said predetermined direction into engagement with the stop on said member, a locking means for the second numeral wheel, control mechanism to cause alternate engagement of said numeral wheel locking means and the storage member locking means, with a predetermined interval of time between such alternate engagement which time interval is approximately equal to the time required for a numeral wheel or storage member to move a distance corresponding to the angular thickness of a stop lug on the storage wheel or member, respectively.

11. A shift register comprising a plurality of ordinarily arranged numeral wheels frictionally mounted upon a drive shaft which is rotatable in a single direction, an interordinal member frictionally mounted on said shaft between each respective pair of numeral wheels, a stop lug carried by each numeral wheel and each member, a lug carried by each numeral wheel and each member for cooperation with a stop on an adjacent member or numeral wheel respectively, a second shaft parallel to the first shaft, a plurality of numeral wheel rotation preventing locks and interordinal member rotation preventing locks carried on said second shaft, means for rotating the second shaft to cause sequential locking of first the numeral wheels and then the interordinal members, and means for rotating the numeral wheel drive shaft at a speed which is at least two times the speed of rotation of the second shaft to cause an interordinal member to be frictionally rotated to a predetermined value representative position under the control of a first locked numeral wheel and then to cause a second numeral wheel to be frictionally rotated to the same value representative position under the control of said interordinal member.

References Cited in the file of this patent

UNITED STATES PATENTS