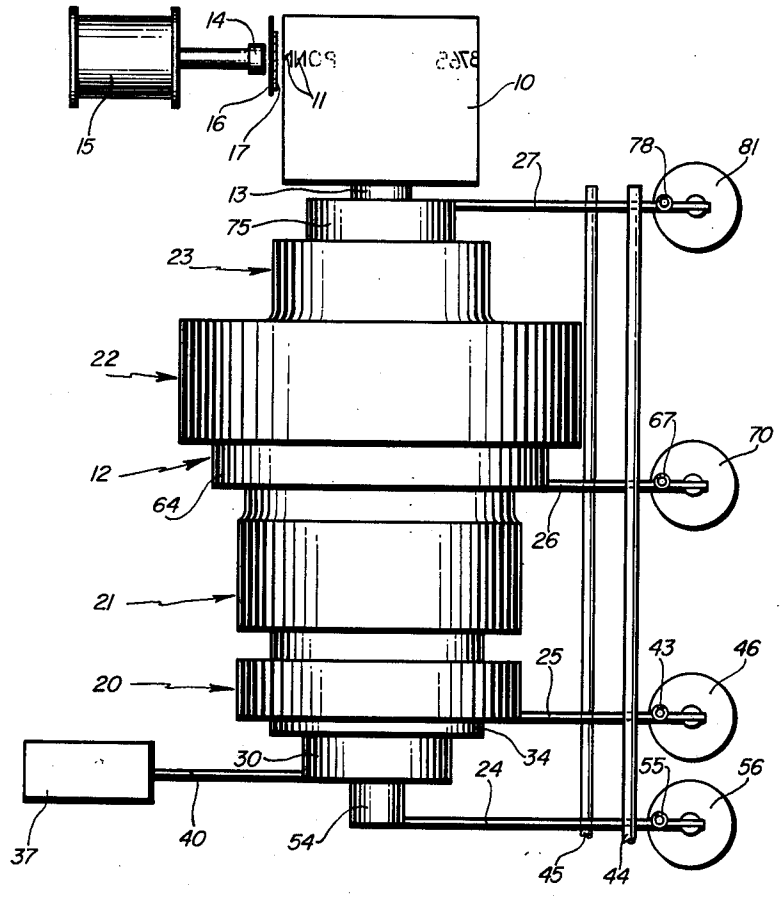
April 17, 1962 J. M. REYNARD 3,029,921

CONTROL MECHANISM

Filed March 9, 1961 2 Sheets-Sheet 1

Fig_1



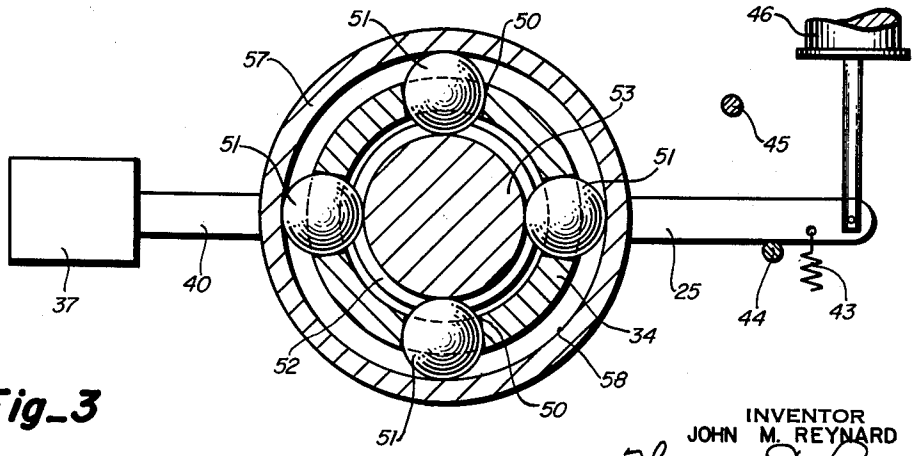


Fig_3

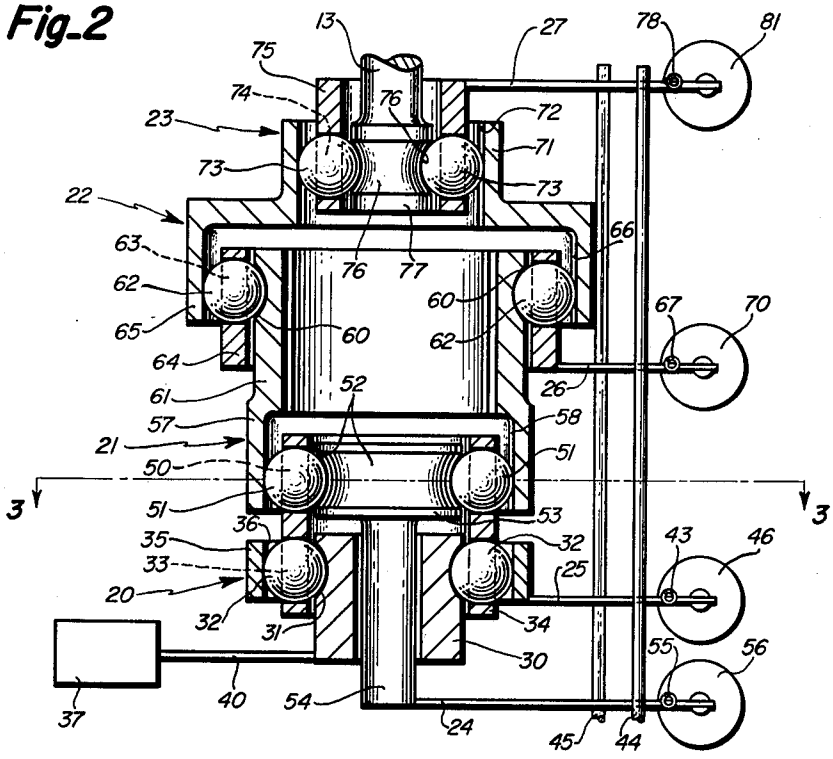
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CONTROL MECHANISM

Filed March 9, 1961 2 Sheets-Sheet 2

Fig_2



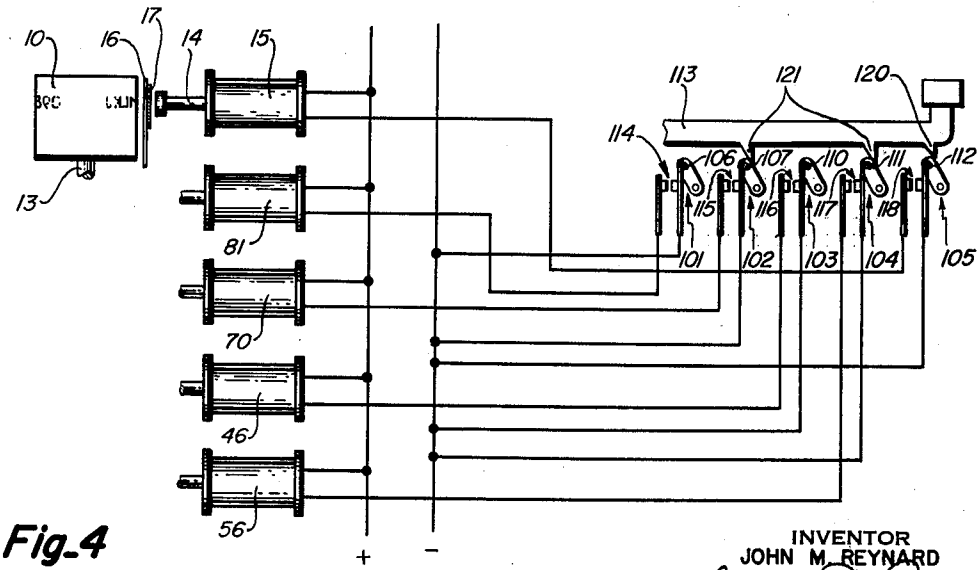


Fig_4

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3,029,921

CONTROL MECHANISM

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12 Claims. (Cl. 197—51)

This invention relates to a differential control mechanism, and more particularly relates to a novel type of differentially operating device for positioning the printing head of a matrix printer, said device having an indexible output element and a plurality of control input members operatively connected to said output element and selectively operable in coded combinations for varying the extent of indexing movement of said output element.

In matrix type printing machines the printing head is successively displaced through predetermined distances in order to serially bring the respective desired type to an operative position at the printing point of the machine. In this type of operation the means provided for displacing the printing head through variable strokes must partake of a very accurate high speed motion. The positioning mechanisms previously proposed or used for controlling such indexing motions of the printing head of matrix machines have not always been satisfactory because of being unreliable in accuracy, having inherent high inertia forces, and/or being too complex and expensive for practical purposes.

One object of the instant invention is to provide a reliably accurate differential positioning mechanism for efficiently indexing the printing head of a matrix type printer.

Another object of the invention is to provide a novel motion transmitting and control mechanism having an output shaft which is adapted to be driven by a plurality of serially interconnected differential or epicyclic units which may be selectively operated in coded combinations so as to cumulatively rotate said output shaft to variable desired extents.

Another object of the invention is to provide a novel positioning mechanism for the printing head of a matrix printer, said positioning mechanism comprising an output shaft which is adapted to be connected so as to be rotated by the collective action of a plurality of interference-fit ball type differential units that are selectively operated in coded combinations so as to rotate said output shaft through various predetermined angles.

Another object of the invention is to provide a novel positioning mechanism for matrix printers and the like whereby a plurality of planetary type differential units are serially connected together so that the output means from each unit is connected to the drive input means for the next unit, the respective control input means for the units thereby being free to modify the movement being transmitted by said differential units.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIGURE 1 is a side elevational view illustrating the orientation of the principal structural parts of the instant apparatus.

FIGURE 2 is an axial sectional view of the instant differential positioning mechanism.

FIGURE 3 is an enlarged cross sectional view taken along section line 3—3 of FIGURE 2.

FIGURE 4 is a schematic view of the mode of interconnecting the control elements of the instant apparatus.

Referring to FIGURE 1 there is shown a conventional type cylindrical matrix printing head **10** having a circumferentially disposed and uniformily spaced array of type **11** mounted on the cylindrical periphery thereof. The head **10** is adapted to be rotatably indexed to successive printing positions by means of a positioning mechanism **12** that has an output shaft **13**; the matrix head **10** being rotatably adjustably clamped on said output shaft **13** by any suitable means. A hammer **14**, operatively mounted and connected so as to be actuated by a solenoid **15**, is provided for cooperating in the usual manner with the various type **11** of the matrix printing head that are moved to the printing point of the machine so that various characters corresponding to said type may be printed on a record sheet **16** through the medium of the inked ribbon **17**. The type for one desired set of characters is located on a 180° arc of the periphery of the head **10** while the type for another desired set of characters is located on the other 180° arc of the head periphery. The head **10** will be rotatably shifted 180° when a change in the character sets to be used is desired. When using either set of type the type head is normally disposed in a central home position and is capable of swinging up to substantially 90° to six discreet printing positions on either side of said home position.

The positioning mechanism **12** is generally comprised of four ball type differential or epicyclic units **20**, **21**, **22** and **23**, FIGURES 1 and 2, which are operatively connected in series so as to form a cumulative motion transmitting means for the output shaft **13**. The four differential units are respectively operated by means of four control input arms **24**, **25**, **26** and **27**; these arms being selectively arcuately displaced in coded combinations so as to cumulatively effect a predetermined rotation of the output shaft **13** and the matrix head **10**. The lowermost differential unit **20** includes a tubular hub **30** that is formed with an annular groove **31** in which four planetary balls **32** are adapted to roll. Each ball **32** is closely retained in one of four uniformly spaced apertures **33** formed in a ball retainer ring **34**. An outer ring member **35** having an inner cylindrical surface **36** is mounted over and surrounds the balls **32**. The three basic elements comprising the first differential unit **20**, namely hub **30**, balls **32** together with the ball retainer ring **34**, and ring member **35**, are relatively radially dimensioned so that when they are assembled as shown in FIGURE 2 an interference fit exists. During the normal operation of the positioning mechanism **12** the tubular hub **30** remains rotatably fixed. When it is occasionally desired to shift the matrix head 180° so that the second set of type may be used the tubular hub is merely rotatably indexed through an arcuate stroke sufficient to produce a 180° rotation of the said output shaft **13**. The means to so index hub **30** may comprise any suitable device, such as a one half revolution clutch or the like, which is diagrammatically illustrated at **37**, **40** of FIGURES 1 and 3. In normal operations however the tubular hub **30** will remain fixed and unless otherwise indicated it will be assumed during the subsequent discussion of the operation of the instant apparatus that this normal condition exists. The ring member **35** is secured to said radially extending control input arm **25** which in turn is biased by means of a spring **43** into normal engagement with the fixed common bar stop **44**. Arm **25** is adapted to be swung into engagement with and held against a fixed common bar stop **45** by means of a solenoid **46**. As will be apparent when the hub **30** remains rotatably fixed a swinging movement of the input arm **25** will cause the balls **32** to roll around the grooved periphery of hub **30**

which in turn will cause the ball retaining ring **34** to rotate about the axis of the unit. This differential type motion of unit **20** will take place in a non-slipping manner due to the said interference fit between the parts.

The ball retainer ring **34** is axially extended and is provided with a second set of four uniformily spaced apertures **50** in which are respectively disposed a second set of four closely fitting planetary balls **51** which are adapted to roll around the annular grooved portion **52** of a second hub **53**. Hub **53** is formed with depending axial shaft portion **54** which extends through the tubular hub **30** and to which is fixed said control input arm **24**. The outer end of arm **24** is biased by means of a spring **55** into normal engagement with the bar stop **44** and is adapted to be rotatably displaced into engagement with the bar stop **45** by means of a solenoid **56**. A second outer ring member **57** having a cylindrical inner surface **58** is mounted over and surrounds said planetary balls **51**. The three basic elements comprising the second differential unit **21**, namely the hub **53**, balls **51** together with the ball retaining ring, and the ring member **57** are relatively radially dimensioned so that when they are assembled as shown in FIGURE 2 an interference fit exists. As will be apparent when the input arm **24** is pivotally displaced the resultant rotation of the hub **53** will be transferred to the balls **51** which in turn transmit this rotational movement to the ring member **57** in an amount dependent on whether or not the balls **51** are permitted by the ball retaining ring **34** to roll or just to rotate on their own geometric axes. Whether or not the ball retainer ring **34** rotates depends on whether or not the input arm **25** has been operated as noted above. This differential type movement of unit **21** will take place in a non-slipping manner due to the said interference fit between the parts.

The ring member **57** is axially extended and is provided with a reduced portion which is formed with an annular groove **60** and which defines the hub **61** of the third differential unit **22**. A third set of planetary balls **62** are mounted for rolling movement in the groove **60** and are respectively closely fitted into the four apertures **63** formed in a third ball retaining ring **64**. A third outer ring member **65** having a cylindrical inner surface **66** is mounted over and surrounds the balls **62**. The ball retaining ring **64** is secured to the said control input arm **26**. Arm **26** is biased by means of a spring **67** into normal engagement with the bar stop **44** and is adapted to be rotatably displaced into engagement with and held against bar stop **45** by means of a solenoid **70**. The three basic elements comprising the third differential unit **22**, namely hub **61**, balls **62** together with the ball retainer ring **64**, and the ring member **65** are relatively radially dimensioned so that when they are assembled as shown in FIGURE 2 an interference fit exists. As will be apparent when the input arm **26** is pivotally displaced the resultant rotational movement of the ball retaining ring **64** will be transferred through balls **62** to the ring member **65** in an amount dependent upon the rotational movement, if any, of the hub **61**. The extent of rotation of hub **61** will, as noted above, be determined by whether or not the input arms **24** and/or **25** have been operated. This differential type movement of unit **22** will take place in a non-slipping manner due to the interference fit between the parts.

The ring member **65** is axially extended and is provided with a reduced portion that defines the ring member **71** of the fourth differential unit **23**. The ring member **71** is formed with an inner cylindrical surface **72** which is mounted over and surrounds a fourth set of four planetary balls **73**. Balls **73** are respectively closely fitted into a set of uniformly spaced apertures **74** formed in a fourth ball retainer ring **75** and are adapted to roll around an annular groove **76** formed in a hub **77**. Hub **77** is integrally connected to the said output shaft **13** of the positioning mechanism and the ball retaining ring **75** is secured to the said control input arm **27**. Arm **27** is biased by means of a spring **78** into normal engagement with the bar stop **44** and is adapted to be displaced into engagement with and held against the bar stop **45** by means of a solenoid **81**. The three basic elements comprising the fourth differential unit, namely hub **77**, balls **73** together with the ball retainer ring **75**, and the ring member **71** are relatively radially dimensioned so that when the parts are assembled as shown in FIGURE 2 an interference fit exists. As will be apparent when the input arm **27** is rotatably displaced the resultant rotation of the ball retaining ring **75** will be transmitted through balls **73** to the hub **77** and output shaft **13** in an amount which is determined by the extent of rotation, if any, of the ring member **71**. The rotation of ring member **71** is as noted above determined by whether or not the input arms **24**, **25** and/or **26** have been operated. This differential type movement of unit **23** will take place in a non-slipping manner due to the said interference fit of the parts.

It will now be apparent that the matrix head **10**, FIGURE 1, may be moved from a central home position to any one of several operative positions by the selective operation of the various control input arms **24**, **25**, **26** and **27** of the differential type positioning mechanism **12**. The ratios of the diameters of the hubs, balls and rings of the different units **20–23** may be adjusted so that the desired sizes of angular displacements of the matrix printing head **10** occur in response to the operation of the respective control input arms **24–27**. By way of illustration the effective relative diameters of the various parts may be adjusted as follows.

Part:	Effective diameter
Balls **32**	D
Groove **31**	2D
Cyl. surface **36**	4D
Balls **51**	D
Groove **52**	2D
Cyl. surface **60**	4D
Balls **62**	D
Groove **60**	4D
Cyl. surface **66**	6D
Balls **73**	D
Groove **76**	D
Cyl. surface **72**	3D

Where D equals approximately ⅛ inch and each input arm is capable of being displaced through an operative arcuate stroke of approximately 15° the output shaft **13** and head **10** will be given substantially the following clockwise (+) and counter clockwise (—) rotative displacements by the noted selective displacement of the control input arms **24–27**.

Control input arms operated:	Degrees of resultant rotation of head 10 from normal central home position
25, 27	+90
25, 27, 24	+75
27	+60
27, 24	+45
25	+30
25, 24	+15
none	0
24	—15
26, 24, 27	—30
26, 25	—45
26, 24, 25	—60
26	—75
26, 24	—90

One diminuitive positioning mechanism **12** has been constructed wherein the overall length is about 1.25 inches and the diameter of the largest one of the cylindrical surfaces (**66**) is in the order of only ¾ of an inch. As will be apparent the operation of such a small size mechanism will involve low inertia forces and such opera-

tions may occur at relatively high speeds with a minimum of noise, vibration, etc.

In effect each of the differential units **20–23** has a drive input means, a control input means and an output means. The output means for one differential unit is connected to the drive input means of the next differential unit; for example, the output means (balls **32** and the lower portion of the ball retainer ring **34**) for the differential unit **20** is connected to the drive input means (balls **51** and the upper portion of the ball retainer ring **34**) for the next differential unit **21**, the control input means for the units **20** and **21** being respectively defined by the ring **35** together with its associated control input arm **25** and the hub **53** together with its associated control input arm **24**. In similar fashion the output means (ring member **57**) of the differential unit **21** is connected to the input drive means (hub **61**) of the differential unit **22**, the control input means here comprising the balls **62** and the ball retaining ring **64** together with the associated control input arm **26**. In turn the output means (ring member **65**) of the differential unit **22** is connected to the input means (ring member **71**) of the differential unit **23**, the balls **73** and ball retainer ring **75** together with the control input arm **27** here constituting the control input means for the differential unit **23**. Although the differential units **20–23** are interconnected in series in the functional sense that the output means of one unit is connected to the drive input means of the next unit, what particular element of a differential unit constitutes the drive input means, the control input means or the output means for that particular differential unit may vary. For example, the hub of one unit may constitute the drive input means for that unit while the hub of the next unit may be an output means for this next unit. Conversely for example, the control input means for one unit may constitute the ring member of that unit while the control input means for the next unit may constitute the planetating balls and retainer of this next unit. Thus any one of the basic parts or elements of any given differential unit may be structurally connected to any one of the elements of the next unit. Further the mode of interconnecting a first to a second differential unit may differ from the mode of interconnecting the second to a third differential unit.

FIGURE 4 shows an exemplary means for controlling the operation of the instant apparatus. Five bails **101**, **102**, **103**, **104** and **105** are pivotally mounted by any suitable means on the machine side frames and respectively have laterally swingable body portions **106**, **107**, **110**, **111** and **112** which extend across the machine and beneath the normal complement of key levers such as **113**. Bails **101–105** are yieldably maintained in their normal FIGURE 4 positions by any suitable spring means and upon counter clockwise displacement are adapted to close the respectively associated normally open switches **114**, **115**, **116**, **117** and **118** which are respectively proximate to said bails and which are suitably supported on the machine frame. Switches **114–117** are electrically connected so as to respectively control the operation of said solenoids **56**, **46**, **70** and **81** which respectively actuate said input arms **24–27**. The switch **118** is electrically connected so as to control the operation of the hammer solenoid **15**. Each key lever is provided with a similar short depending camming tooth **120** and in addition is provided with a coded number of longer camming teeth **121**. The teeth **121** are adapted to arcuately displace the respective adjacent associated bails and thereby close the related switches in response to the selective depression of the key levers.

In operation after any given coded combination of switches **121** have been closed and the related control input arms have been thereby actuated to properly position the matrix head **10** the relatively short tooth **120** of the key lever will then displace bail **105** so as to close switch **118** and thereby energize the hammer solenoid **15** so as to print the desired character on the record sheet **16**. It will be apparent here that due to the relative shortness of tooth **120** no printing action will occur until after the positioning mechanism **12** has displaced matrix head **10** to the desired indexed position. As different key levers having different coded numbers and positions for teeth **121** are successively depressed, different type **11** will be sequentially brought to printing position by the action of the differential positioning mechanism **12**.

When the second set of type on the other 180° half of the periphery of head **10** is to be used the shift means **37**, **40** are operated to thereby displace the head through 180° from the normal home position to an alternate home position. Thereafter the selective operation of the control input arms **24–27** will serve to bring the various type of this second set to printing positions in a manner similar to that above described for said first set of type **11** to be used.

If after prolonged use of the instant apparatus a slight amount of slippage has occurred between the various parts of the differential positioning mechanism **12** then the matrix head **10** may be unclamped from the output shaft **13**, rotatably adjusted to proper phase relation and then reclamped on said output shaft **13**. Thereafter all the type **11** and all the differential units will again be in proper phase condition. It will be apparent that conventional type gears may be used in place of the various balls, ring members and hubs; and that a similar differential positioning mechanism can be correspondingly used to control an axial shifting movement of the matrix head **10** where more than one circumferential band or row of type **11** is to be mounted on said matrix head.

The instant mechanism **12** has been shown and described here as a positioning means for matrix printers; however it may be utilized in several other applications with equal facility; for example, the mechanism may be employed as an arithmetic unit wherein movement of the output shaft **13** represents an algebraic sum of quantities represented by the displacements of the control input arms **24–27**. Also it will be noted that the time displacement characteristics of the motion of any one of the control input arms **24–27** will produce corresponding time-displacement characteristics in the resultant effects on the movement of the output shaft **13**. Further the unit or mechanism **12** may be used simply as a motion transmitting means wherein a fixed or variable amplification or reduction of an input movement is desired.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration only and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

The invention claimed is:

1. In a printing device; a matrix printing head, a plurality of type mounted on said matrix head, means for creating a printing pressure between said head and a record sheet that is to be printed on, a positioning mechanism for sequentially variably positioning said matrix head, said positioning mechanism comprising a plurality of coaxially arranged differential units which are effectively serially connected between each other and said matrix head, each of said differential units including a hub element, a pluarity of planetating elements adapted to roll around said hub element, and an output element, a control input arm operatively connected to one of the elements of each of said differential units, and control means for selectively operating said input arms.

2. A position mechanism for matrix printers and the like; comprising a plurality of differential type units, a first one of said units having three basic parts namely a hub portion, at least one rollable element, and an outer member, one of said parts constituting an output means for said unit, a second one of said parts constituting a

drive input means for said unit, and the third one of said parts constituting a control input means for said unit, a second one of said units also including three basic parts that are respectively similar to those of the first differential unit, a third one of said units also including three basic parts that are respectively similar to those of said first unit, the output means of the first differential unit being connected to the drive input means of said second differential unit and the output means of said second differential unit being connected to the drive input means of said third differential unit whereby selective operation of the three control input means for said units will cause variable displacements for the output means of said third differential unit, the mode of interconnecting said units being such that connection between the parts of said first and second differential units is different from the connection between the parts of said second and third differential units.

3. Apparatus as defined by claim 2 wherein in at least one of said differential units, the hub portion is defined by a cylindrical member, the rollable element is a ball, and the outer member is a ring member which surrounds said balls and hub portion, and wherein said parts when assembled have a radial interference fit so as to thereby make possible a non-slipping connection therebetween.

4. A positioning mechanism for matrix printers and the like; comprising a first differential unit having three basic parts namely a hub portion, at least one rollable element and an outer member, one of said parts constituting an output means for said unit, a second one of said parts constituting a drive input means for said unit, and the third one of said parts constituting a control input means for said unit, a second differential unit which also has three basic parts that are respectively similar to those of said first differential unit, the output means for said first unit being connected to the drive input means for the second unit such that the individual actuation of the control input means for each of said units will respectively produce different rotative displacements of the output means of said second unit.

5. Apparatus as defined by claim 4 wherein the output means for the first differential unit is defined by a different one of the three basic unit parts than the output means for said second differential unit.

6. Apparatus as defined by claim 5 wherein the control input means for the first unit is defined by a different one of said basic parts than the control input means for said second unit.

7. Apparatus as defined by claim 5 wherein the output means of the first differential unit comprises the rollable element of said first differential unit, and the drive input means of the second differential unit comprises the rollable element of said second differential unit.

8. Apparatus as defined by claim 5 wherein the output means from the first differential unit comprises the outer member of said first differential unit, and the input drive means of the second differential unit comprises the hub portion of said second differential unit.

9. Apparatus as defined by claim 5 wherein the output means from the first differential unit comprises the outer member of said first differential unit, and the drive input means of the second differential unit comprises the outer member of said second differential unit.

10. Apparatus as defined by claim 5 wherein the rollable element of at least one of said differential units comprises a ball that is adapted to roll along the respective effective outer and inner surfaces of the associated hub portion and outer member, these three basic parts of said one differential unit being relatively dimensioned and assembled so as to have a non-slipping interference fit therebetween.

11. In a printing device; a matrix printing head, a plurality of printing type mounted on said matrix head and adapted to be selectively moved to a predetermined printing point, means for creating a printing pressure between the selected type located at said printing point and a record sheet that is to be printed on, a positioning mechanism for variably displacing said matrix head so as to successively bring different type to said printing point, said positioning mechanism comprising a plurality of coaxially arranged differentially operating units which are serially interconnected, each unit having a hub element, at least one planetating element adapted to roll around said hub element, and an output element all interconnected so as to form a differentially operating unit, a control arm connected to one of said elements in each of said units, each control arm being movable to rotatably displace said matrix head to a predetermined extent, and means operable to sequentially actuate different coded combinations of said control arm.

12. Apparatus as defined in claim 11 wherein at least one of said differentially operating units includes a hub, a plurality of balls and an outer ring member, said balls adapted to frictionally engage and roll around the outer and inner peripheries of the associated hub and ring member respectively.

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