United States Patent [19]

Miller et al.

[11] **3,877,035**

[45] **Apr. 8, 1975**

[54] **EVENT MARKER FOR GRAPHIC RECORDER**

[75] Inventors: **Roger L. Miller,** Lansdale; **Joseph F. Steelman,** Harleysville, both of Pa.

[73] Assignee: **Leeds & Northrup Company,** North Wales, Pa.

[22] Filed: **Feb. 1, 1974**

[21] Appl. No.: **438,825**

[52] **U.S. Cl.** ..... **346/49;** 310/13; 346/139 R

[51] **Int. Cl.** **G01d 15/24**

[58] **Field of Search** ..... 346/49, 112, 139 R; 310/30, 12, 14, 13, 27; 335/222, 223; 318/135

[56] **References Cited**

UNITED STATES PATENTS

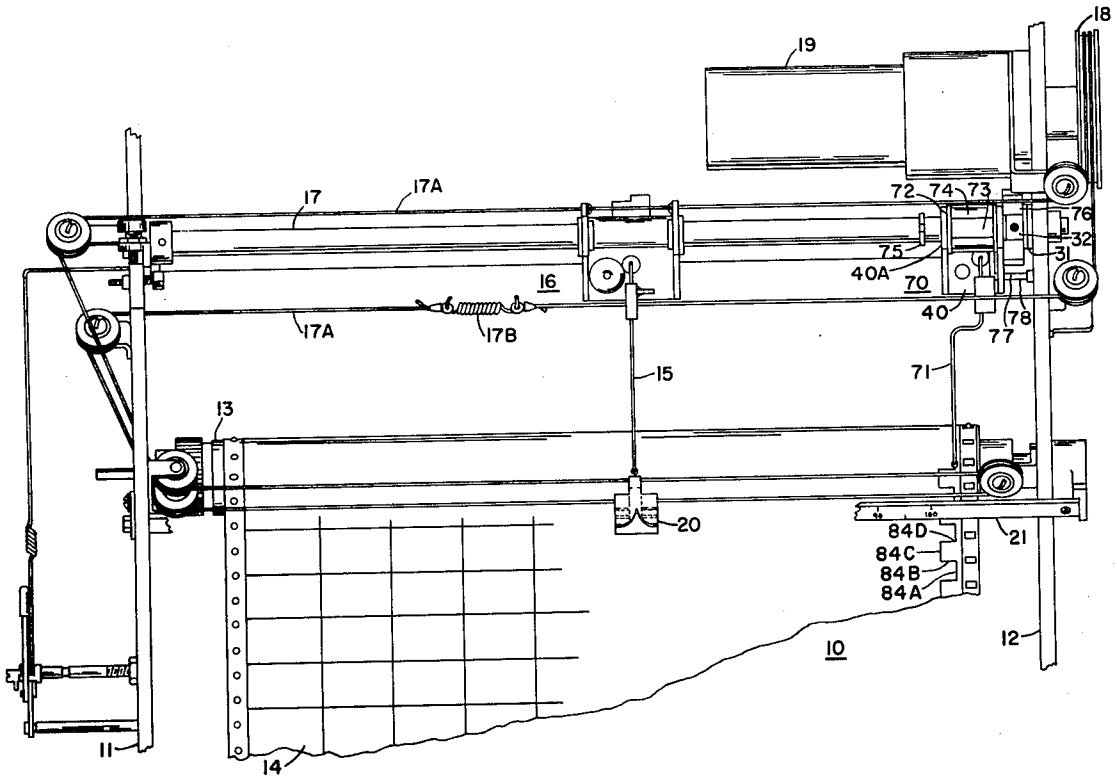
2,581,133	1/1952	Niemann	346/32
2,724,631	11/1955	Ruhland	346/49
3,184,754	5/1965	Peltola	346/112
3,543,279	11/1970	Rempel et al.	346/141
3,739,384	6/1973	Harkins	346/140 X

Primary Examiner—Joseph W. Hartary
Attorney, Agent, or Firm—Philemon J. Moore; Raymond F. MacKay

[57] **ABSTRACT**

An event marker which is supported on a carriage which includes bearing structure slideable along a longitudinally fixed guide shaft and wherein a solenoid is supported by the carriage in concentric relation with the bearing structure and the guide shaft. The guide shaft is made of ferromagnetic material so that when the solenoid is energized it will produce a magnetic flux which in turn produces magnetic poles on the guide shaft which causes the solenoid and therefore the marker carriage to be drawn toward the longitudinal center of the guide shaft. Stop structure is provided to limit movement of the event marker to a fixed distance along the shaft and near an extremity thereof. Biasing means which may be a magnet or a spring urges the marker toward one position when the solenoid is deenergized. When the biasing means is a permanent magnet a cover of ferromagnetic material partially surrounds the solenoid so that the marker assembly will be attracted by the magnet when the solenoid is deenergized and repelled by the magnet when the solenoid is energized. When the biasing means is a compression spring the spring is compressed when the solenoid is energized. In different modifications of the invention the guide shaft may comprise both ferromagnetic and weak magnetic portions to minimize the amount of power needed to move the event marker along the guide shaft. This event marker may be mounted on the same guide shaft used to guide a marker driven by a servo system and both markers may be raised from and lowered into marking engagement with a chart by the same marker lifting means.

15 Claims, 6 Drawing Figures



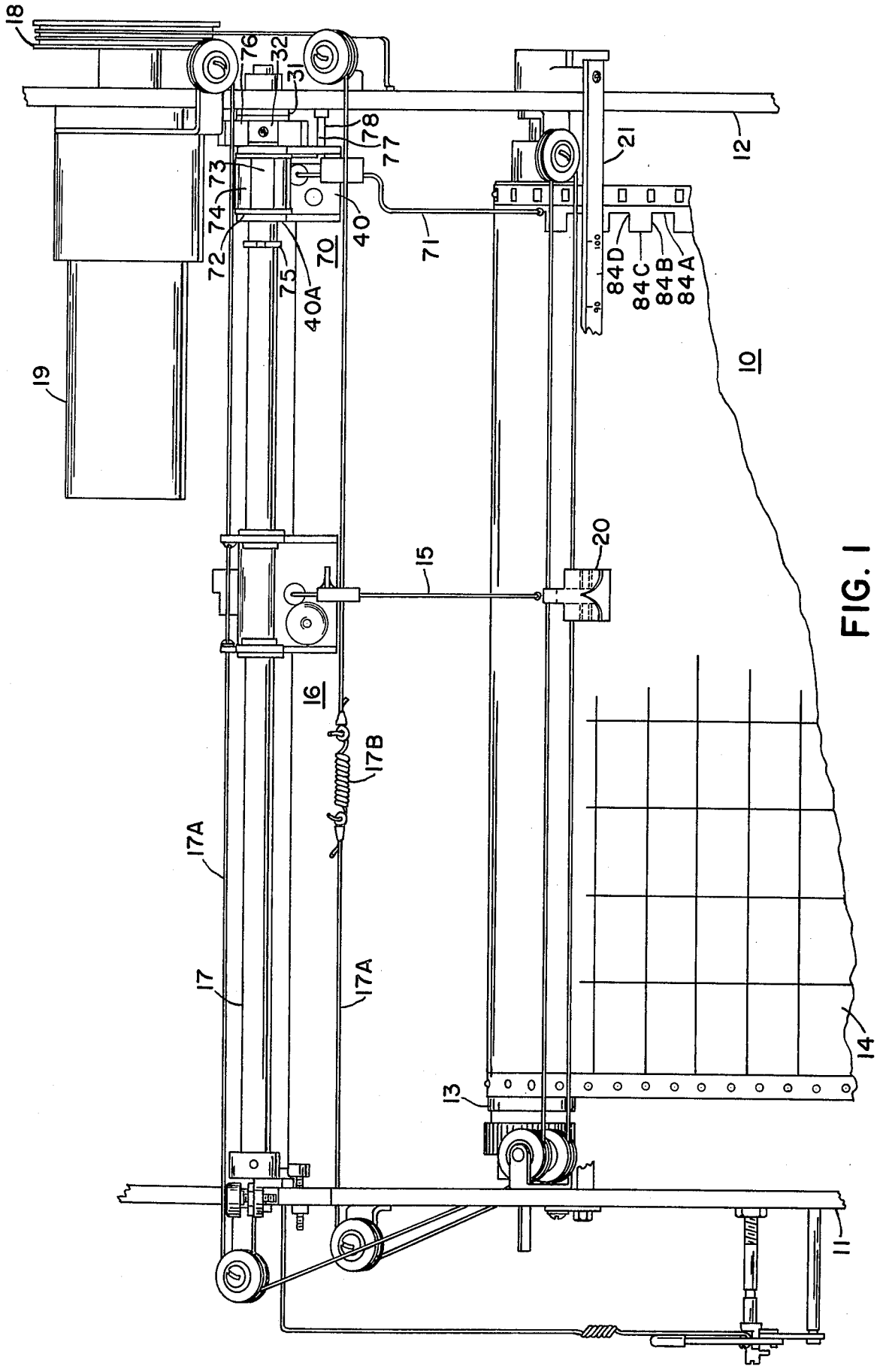

18
76
32
31
78
77
73
74
72
75
40A
70
40
71
12
21
84D
84C
84B
84A
10
19
20
15
16
17B
17A
17
17A
13
14
11

FIG. 1

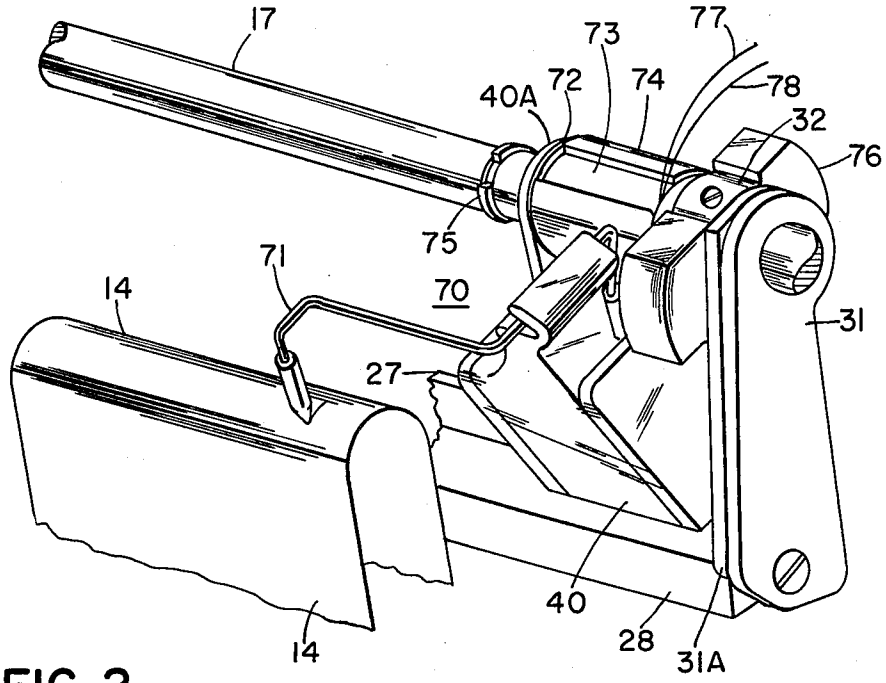

17
73
77
40A
72
74
78
32
76
75
71
70
14
31
27
40
28
31A
14

FIG. 2

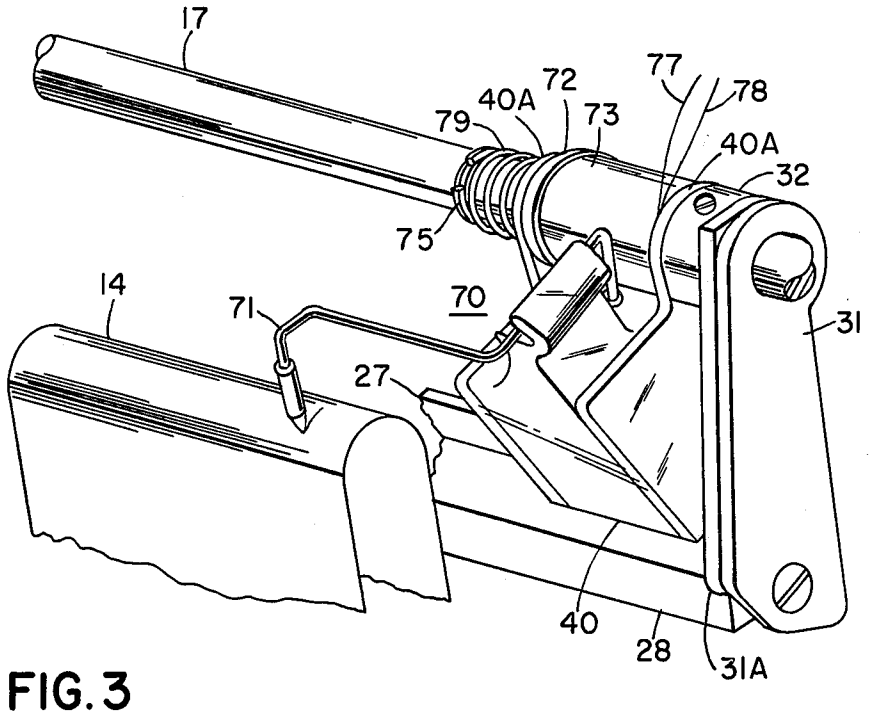

17
77
72
78
79
40A
73
40A
32
75
14
71
70
31
27
40
28
31A

FIG. 3

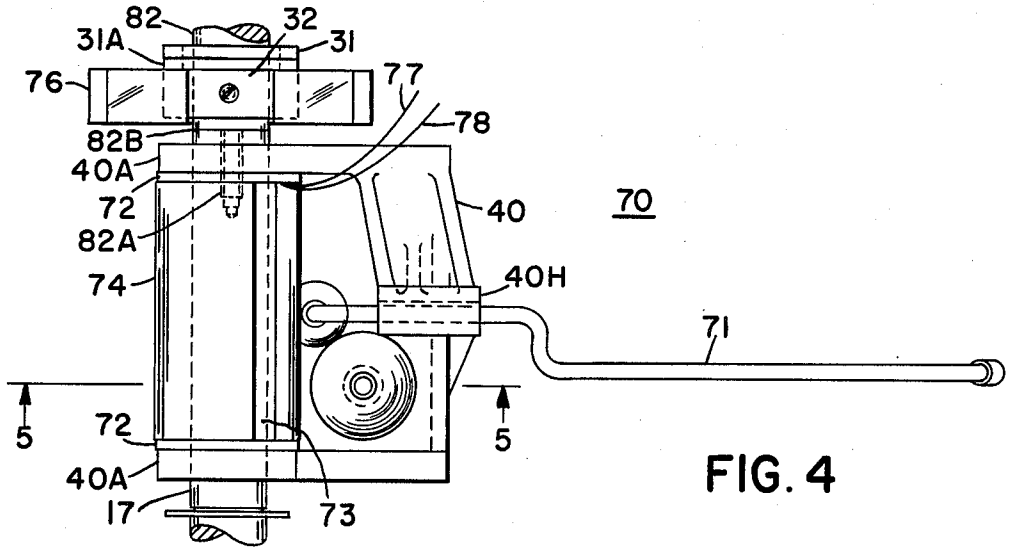


FIG. 4

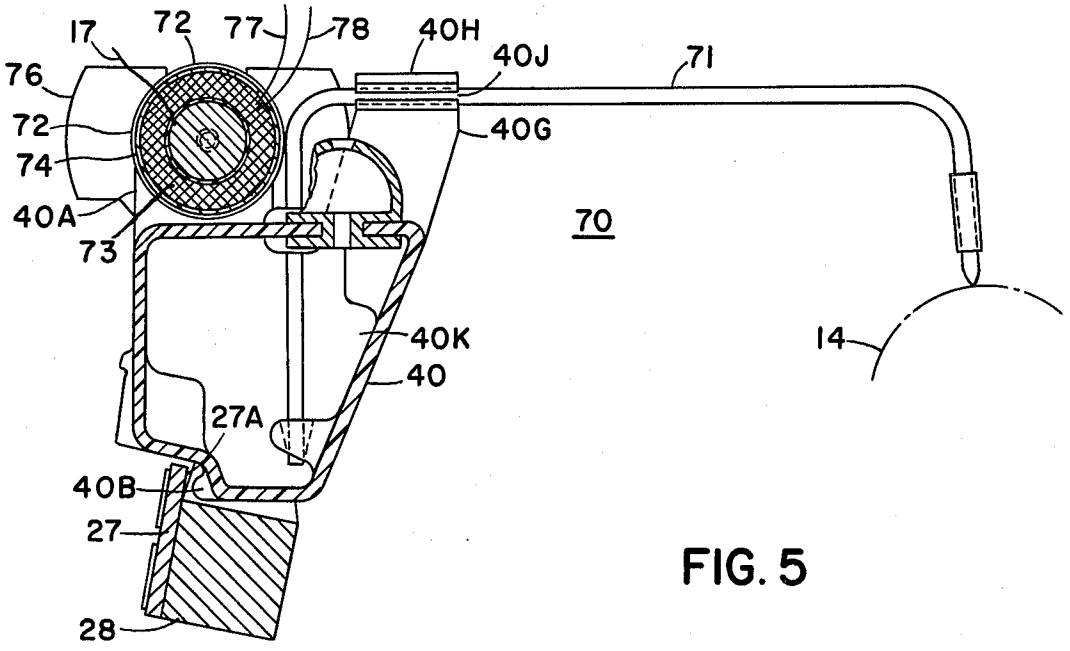


FIG. 5

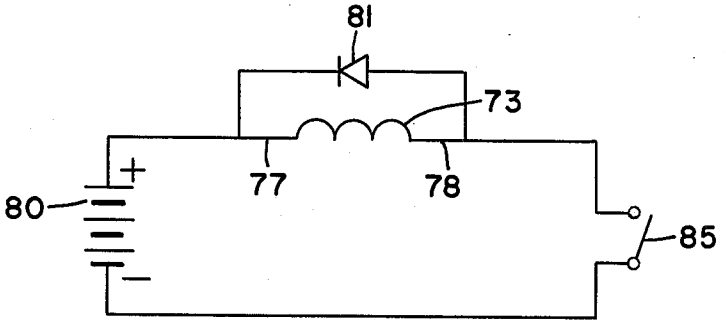


FIG. 6

EVENT MARKER FOR GRAPHIC RECORDER

BACKGROUND OF THE INVENTION

1. Field of the Invention

Applicant's invention is for an event marker for a graphic recorder which is subject matter most likely to be found in the U.S. Pat. Office Official Class for Recorders and more particularly in subclasses relating to markers and/or driving means therefore.

2. Description of the Prior Art

Heretofore it has been customary to supply graphic recorders with event markers supported on a pivoted arm having an armature associated therewith such that the arm could be moved a short distance by means of an electromagnet which attracted the armature. It has also been well known in the prior art to operate event markers of cam structures and/or a solenoid having a plunger to which the event marker was directly connected or linked to be moved when the plunger was drawn into the solenoid.

As exemplified in U.S. Pat. Nos. 2,581,133-A. W. Niemann and 3,184,754-V. K. Peltola, marking structures for graphic recorders have been provided wherein a carriage which supports the marking element additionally supports a coil for movement in a magnetic field produced by one or more strong permanent magnets with one or more pole pieces which complete the path of flux for the magnetic circuit.

Applicants have found that an event marker which requires very little power for its operation and which has a very low temperature rise with continued energization can be constructed utilizing a solenoid coil carried by a marker carriage and concentrically disposed about the end of a guide rod of ferromagnetic material. Such a construction does not require the permanent magnet and pole structures of the above mentioned prior art devices and additionally make it possible to use standard marker components for a recorder for reduction of inventory and cost.

Summary of the Invention

In accordance with applicants' invention a marker carriage is utilized which carries a solenoid which surrounds the axis of bearing structure for the carriage so that it will be concentrically disposed with respect to a guide shaft for the carriage. A marker-carriage guide-shaft of ferromagnetic material is adapted to guide the carriage with respect to a recorder chart and stop structure mounted on the guide shaft near an extremity thereof defines the extent of movement of the event marker along the shaft and across the chart. When the solenoid of the event marker is energized there is produced a magnetic flux which produces magnetic poles on the guide shaft of a polarity which causes the solenoid and therefore the marker carriage to be drawn toward the longitudinal center of the guide shaft. It has been found that as the length of the guide shaft is increased from about 3 inches to something over 12 inches the amount of power to effect initial movement of a solenoid from a position of rest at the extreme end of the shaft toward the longitudinal center of the shaft becomes less as the length of the shaft increases. In view of the foregoing it has thus been found practical to journal a carriage for an event marker on the same guide shaft used for other marking carriages of a graphic recorder. More particularly the guide shaft of a strip chart recorder of the self-balancing type wherein a marker is moved across a chart of substantial width by a servo mechanism can also be employed to guide the event marker support carriage or carriages of one or more event markers.

It has additionally been found that the increase in power necessary to move a solenoid toward the center of a ferromagnetic shaft is substantial as the solenoid is positioned further and further away from the end of the shaft and closer and closer to the longitudinal center thereof. In view of this it is preferable when using event markers in accordance with applicants' invention to make the guide shaft of a recorder in two parts one of which is of ferromagnetic material and the other of which is of diamagnetic or paramagnetic material that is to say a weak magnetic material or one which is non-magnetic so that the portion of the shaft which extends beyond or outwardly of the solenoid in a direction opposite the direction of movement of the solenoid when energized will be of weak or nonmagnetic material thus effectively positioning the marker carriage at the end of the ferromagnetic portion of the shaft. Such a construction permits the use of a minimal amount of power for energizing the solenoid, hence there is very little rise in temperature when the solenoid is energized for an extended period of time and the mechanism is safe for an operator to touch without getting burnt.

As those skilled in the art are fully aware, event markers are utilized for recording periods of operation or non-operation of a piece of machinery, recording integrated values of a condition, or recording other types of information which require a marker to move over a very narrow portion of a recorder chart. In order to limit the path of travel of the event marker of our invention stop structure is provided on the guide shaft together with biasing means which holds the event marker carriage in one position when the solenoid is deenergized and sets the limit of travel for the carriage when the solenoid is energized. While a compression spring may be utilized for biasing the marker carriage to one position while the solenoid is deenergized it has been found preferable to utilize a permanent magnet in substantially surrounding relation with the guide shaft. The magnet is magnetized in a manner such that the plane surface adjacent the marker carriage is for example a north pole and the plane surface thereof away from the carriage is a south pole. When such a magnet is utilized it has been found desirable to employ a sleeve or collar of ferromagnetic material in substantially surrounding relation with respect to the solenoid. With the solenoid deenergized the sleeve is attracted by the permanent magnet to hold the marker carriage in one position. When the solenoid is energized the direction of current flow therethrough is chosen so that the polarity of the field produced by the magnetic flux of the solenoid is in a direction such that the marker carriage will be repelled by the permanent magnet. This repelling force is in a direction to aid the force tending to produce movement of the marker carriage toward the longitudinal center of the shaft of ferromagnetic material as a result of the magnetic flux of the solenoid producing magnetic poles on the shaft which causes the solenoid to seek the center of the shaft. When the solenoid is deenergized the permanent magnet will again draw the marker carriage toward the "solenoid-deenergized-position" due to the attractive force of the permanent magnet on the split sleeve of ferromagnetic material around the solenoid. From the foregoing it is evi-

dent that in the spring biased modification the opposing force of the spring increases as the pull of the solenoid decreases whereas in the permanent magnet modification the repelling force between the permanent magnet and solenoid aids initial movement of the solenoid and as the solenoid force decreases so does the pull of the permanent magnet on the sleeve.

It is an object of applicants' invention to provide: a graphic recorder having an event marker comprising; a longitudinally fixed guide shaft including ferromagnetic material, a marker assembly having a means for supporting a marker and means to support nonmagnetic bearing structure for sliding engagement with the guide shaft, and a coil of wire wound about the axis of the bearing structure to form a solenoid which when energized will produce a magnetic flux which in turn produces magnetic poles on the guide shaft which cause the solenoid and therefore the marker assembly to be drawn toward the longitudinal center of the shaft. The shaft includes stop structure and means biasing the marker assembly toward an element of the stop structure. While the biasing means may be a compression spring it is preferably a permanent magnet in which case a split cover or sleeve of ferromagnetic material substantially surrounds the solenoid. While the guide shaft may be composed entirely of a ferromagnetic material in some modifications the guide shaft is provided with an end or end portions of weak magnetic material.

In accordance with applicants' invention it is also an object to provide an event marker assembly using a preferred form of marker carriage comprised of wall structure of non-magnetic material with portions of the wall structure projecting to form a pair of spaced-apart ear portions having aligned openings. A spool of non-magnetic material has a boss on the outside face of each flange of dimensions such that the spool is held securely in the aligned opening of the ear portions. The internal diameter of the spool forms bearing structure for sliding engagement with the guide shaft of a recorder. The spool has wire wrapped around it to form a solenoid which in some modifications includes a split sleeve or cover of ferromagnetic material.

It is further an object of our invention to provide a graphic recorder having one or more servo driven marking means and one or more event marking means. The recorder has at least one guide shaft at least the major portion of which is of ferromagnetic material. This shaft is common for use to guide a servo driven marking means and an event marking means. Means are disposed with respect to the shaft to form stop structure. The shaft includes means disposed with respect to the shaft for biasing an event marking means toward an element of the stop structure. An event marker is supported by a carriage including bearing structure for journaling the carriage on the guide shaft and there is a coil of wire surrounding the axis of the bearing structure to form a solenoid which when energized produces a magnetic flux which in turn produces magnetic poles on the guide shaft which cause the solenoid and therefore the event marker to move toward the center of the guide shaft until movement thereof is arrested by another element of the stop structure.

The foregoing and other objects of our invention will be more fully understood after reading applicants' specification with reference to the drawings and reading applicants' claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of the essential parts of one type of recorder having an event marker in accordance with applicants' invention,

FIG. **2** is a partial perspective on an enlarged scale illustrating the disposition of parts of the recorder and an event marker of FIG. **1**,

FIG. **3** is a partial perspective on an enlarged scale illustrative of the disposition of parts for another form of applicants' invention,

FIG. **4** is a plan view on an enlarged scale further illustrating the relationship of parts of the event marker of FIGS. **1** and **2**,

FIG. **5** is a side elevation partly in section taken along the line **5,5** of FIG. **4**, and

FIG. **6** is a wiring diagram illustrating how electrical connection is made to the solenoid of applicants' marker assembly.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** illustrates the essential parts of an automatic self-balancing strip chart recorder **10**. Side plates **11** and **12** are part of a frame the details of which are conventional and therefore not shown. Supported for rotation in the side plates **11** and **12** is a chart metering roll **13** for advancing a chart **14** in any customary manner. A pen **15** carried by a pen assembly **16** extends into a position overlying the chart for recording thereon. The pen assembly **16** is journaled on a guide shaft **17** and is moved back-and-forth along the shaft parallel to the chart by means of a cable **17A** which is moved by a drum **18** connected to the output shaft of a recorder balancing motor **19**. There is also mounted on a loop of cable **17A** an index **20** which cooperates with a scale **21** to indicate to an observer the value of a condition being recorded on the chart. The operation of self-balancing strip chart recorders is well known to those skilled in the art, however, for additional information one may refer to U.S. Pat. No. 2,113,164-A. J. Williams, Jr., which is a patent describing such a recorder.

The foregoing general description of the recorder **10** is taken from U.S. Pat. No. 3,739,384-Samuel J. Harkins, which is assigned to applicants' assignee. Since applicants' invention is conveniently practiced utilizing a modified marker assembly similar to that shown in the patent and the use of the modified assembly has other advantages, reference may be had to the patent for further details of the recorder structure and pen assembly so that it is unnecessary to repeat all of the material in the present specification.

Still referring to FIG. **1** it may be noted that recorder **10** includes an event marker assembly **70**. In order that one may conveniently refer back to the above mentioned Pat. No. 3,739,384 reference numerals which describe parts of subject assembly which are new bear reference numbers higher than **70**. Parts which are the same as those utilized in the marker assembly **16** of the patent will be the same as those used in the above mentioned patent.

Referring to FIGS. **1** and **2** it may be observed that marker assembly **70** includes a marking element **71** shown in the form of a pen. It is to be understood that while a pen is used for illustrative purposes that any type of marking element may be used such as a stylus for marking on pressure sensitive paper, a heated stylus

for marking on heat sensitive paper, or any other form of chart marking device. The event marker **71** is carried by a marker carriage **40** which may be made of a transparent or translucent molded plastic such as a selected one of General Electric Company's LEXAN polycarbonate resins so as to form a single piece or the carriage **40** may be of three pieces comprised of a center section and end plates. The carriage has a pair of upstanding ear portions **40A** and a central body portion comprised of wall structure of non-magnetic material defining an internal cavity for the storage of a supply of ink therein. While pen and ink are used for illustrative purposes it is to be understood that one of the alternative marking devices suggested may be mounted on the carriage **40** and the ink well not used or a similarly constructed carriage may be employed omitting an ink well. The spaced-apart ear portions **40A** have aligned openings which support a spool **72** about which is wrapped wire to form a solenoid **73** in surrounding relation with the guide shaft **17** of the recorder. In accordance with applicants' invention the guide shaft **17** is comprised of a ferromagnetic material which may be a ferromagnetic stainless steel such as is designated in the trade as No. 416 stainless steel. As will later be described, shaft **17** preferably will include an end portion of weak magnetic material. In substantially surrounding relation with the solenoid **73** is a split sleeve or cover **74** of ferromagnetic material which may be of the same composition as the material of the guide shaft **17.**

Mounted in substantially surrounding relation with a collar **32,** which is one of a pair of collars which positions the guide shaft **17** in recorder frame **11,12** is a permanent magnet **76,** the function of which will be more fully described in connection with FIG. **2,** and a snap ring or "C" washer **75.** Leads **77** and **78** for energizing the solenoid **73** extend to the frame structure **12** where they are supported and continue on to an energizing circuit not shown.

When the solenoid **73** is deenergized the marker assembly **70** is held against the magnet **76** due to the attractive forces of the magnet for the sleeve **74** of ferromagnetic material. When in that position the marker **71** will cause a straight line **84A** to be drawn near the right hand margin of the chart **14** as viewed in FIG. **1.** When the solenoid **73** is energized magnetic flux is produced by the solenoid and in a manner known to those skilled in the art the flux produces magnetic poles on the guide shaft **17** of ferromagnetic material which urge the solenoid and therefore the marker assembly to be drawn toward the longitudinal center of the shaft.

For a more complete understanding of the construction and operation of a solenoid and plunger reference may be had to an Electrical Engineering text book including chapters on magnetism and electromagnetism such as "A course in Electrical Engineering", Volume 1, Direct Currents, by Chester L. Dawes, Third Edition, Fourth Impression, published by the McGraw-Hill Book Company, Inc. 1937. On page 238 of the Dawes book there begins section 166 entitled "Commercial Solenoids or Eletromagnets" wherein mention is made of the fact that, "A very useful type of electromagnet is the solenoid and plunger type, the operation of which is indicated in FIG. 171. The flux due to the solenoid produces magnetic poles on the plunger. The pole nearer the solenoid will be of such sign that it will be urged along the lines of force (see Par. 144, p. 211), and in such a direction as to be drawn within the solenoid.

A position of equilibrium is reached when the center of the plunger is at the center of the solenoid (FIG. 171)."

Since the solenoid and plunger type of electromagnet is not applicants' invention and descriptions thereof are readily available in prior art literature it is deemed unnecessary to include herein a detailed description thereof for an understanding of applicants' invention. The permanent magnet **76** is magnetized in a manner such that the plane surface adjacent the marker carriage **40** is, for example, a north pole and the plane surface thereof away from the carriage is a south pole. The direction of current flow through the solenoid **73** is chosen so that the polarity of the field produced by the magnetic flux of the solenoid is in a direction such that the solenoid will simultaneously be repelled by the permanent magnet as the solenoid is drawn toward the longitudinal center of the shaft **17.** This results in movement of the marker carriage **70** toward the longitudinal center of shaft **17.** The movement continues until the carriage is stopped by the stop consisting of snap ring **75.** As the marker assembly moves to the left toward the stop, line **84B** will be traced on the chart and as long as the marker **71** is held in the left hand position due to continued energization of the solenoid **73** a mark **84C** will be made on the recorder chart as it is moved downwardly by the chart metering roll **13.** When the solenoid is deenergized magnet **76** will attract the marker assembly **70** due to the magnetic pull of the permanent magnet on the sleeve **74** so as to return the marker assembly to its original position. When this happens a line **84D** will be made on the chart. Energization and deenergization of the solenoid **73** is effected in accordance with the on or off position of a switch supplied by circuitry not shown which is generally located externally of the recorder.

In FIG. **2** the marker assembly **70** of FIG. **1** is shown on an enlarged scale. As may be seen in both FIGS. **2** and **3** the collar **32** is secured to shaft **17** by means of a screw and the "C" washer or snap ring **75** is retained in a groove in guide shaft **17.** In view of the fact that the ear structure **40A** is spaced rearwardly of the body **40** the weight distribution for the marker assembly **70** which, as illustrated is comprised of a pen and ink well, is such as to bias the pen **71** toward the chart **14** by gravity alone. However, if deemed desirable additional biasing means may be supplied in a manner fully disclosed in the above mentioned Pat. No. 3,739,384.

Referring to FIG. **4,** it may be noted that shaft **17** includes an extension portion **82** which is comprised of a short length of shaft of weak magnetic material such as No. 303 stainless steel secured to shaft **17** which is of ferromagnetic materials as by a centrally threaded portion **82A** of smaller diameter screwed into a mating hole in the end of shaft **17** to form the juncture **82B.** It has been found that considerably more power is required to effect movement of a solenoid along a shaft of ferromagnetic material the further the solenoid is from the end of the shaft and the closer it is toward the center of the shaft. In order to minimize the power requirements for operation of applicants' event marker the shaft **17** is made to include the extension portion **82** of weak magnetic material so that effectively the solenoid will be as close as is reasonably possible to the end of the ferromagnetic shaft. The juncture between shaft

17 and the end portion 82 is selected to be substantially at the outside face of the body 40, as shown, in order that this joint does not have to be passed over by the bearing structure comprised of the spool 72 in view of the fact that machining parts to commerical tolerances may result in the joint being rough which would cause excessive bearing wear. The marker assembly 70 has been shown displaced slightly away from the magnet 76 in order clearly to show the junction point 82B between shaft 17 of ferromagnetic material and its extension 82 of weak magnetic material. It has been found desirable to utilize as the material for the spool 72 a material such as E. I. DuPont de Nemour's DELRIN, acetal resin since it is a good bearing material and easily worked. Other nonmagnetic materials could be used.

Referring to FIG. 5, which is a view taken along the line 5,5 of FIG. 4, there is illustrated in greater detail how the plastic body 40 of Pat No. 3,739,384 is desirably utilized with applicants' invention. The upstanding ear portions 40A (only one of which is shown in FIG. 5) of the body 40 include aligned openings of a size to receive the hubs of spool 72. After wire is wound on the spool to form the solenoid 73 and the split cover or sleeve 74 may be installed and the completed spool may then be snapped into position between the upstanding ear portions 40A. This construction lends itself to easy replacement of the coil should the need arise. It may be noted that as is fully described in Pat. No. 3,739,384 there is a cross member 28, see FIGS. 2, 3, and 5, which carries a plate 27 which extends the length thereof. This assembly of cross member and plate is fully described in the above named patent. The combination is pivoted for movement about the guide shaft 17 and its extension 82, if an extension be include, for movement toward and away from the bottom of body 40. Body 40 includes a protrusion 40B which is adapted to cooperate with portion 27A of the plate 27. As is described in the patent cross member 28 may be moved from the position shown in FIG. 5 where the upper edge of plate 27A is spaced from protrusion 40B into a position where 27A engages 40B and rotates the body 40 counterclockwise about the shaft 17 so as to raise the pen 71 from the chart 14. Inasmuch as the mechanism for moving cross member 28 is fully described in the above patent it is deemed unnecessary to repeat the description here.

In FIG. 6 there is diagrammatically illustrated a power supply 80 which may be of 6 or 7 volts D.C. for energizing the solenoid 73 via a pair of leads 77,78. A switch 85 controls energization of the solenoid. This switch may be operated by an integrator, for example, or by other means for any other purpose to inscribe lines 84A–84D on the chart 14. It has been found that deenergizing a solenoid in an environment such as a potentiometer type strip chart recorder which contains low level circuitry that on occasion transient interferences are produced. While not necessary for operation of applicants' event marker it has been found useful to include a diode 81 in shunting relation with the solenoid 73 to avoid the affect of transients on the servo driven marker 15.

FIG. 3 shows another modification of applicants' invention where instead of using a permanent magnet to maintain the event marker 70 in a fixed deenergized position there is utilized a compression spring 79 disposed between stop member 75 and the adjacent ear member 40A. When the solenoid 73 is energized and deenergized the magnetic forces produced move the assembly toward the stop member 75 and the spring moves the assembly away from the stop member and the pen 71 will scribe lines similar to 84A–84D as shown in FIG. 1. With this arrangement the split cover or sleeve 74 is omitted. Use of the permanent magnet modification of applicants' invention has been found preferable since the least amount of power is needed for operation of the event marker. In prior art devices using the magnet and armature type of construction it was found necessary to utilize enough power so that when the magnet was continuously energized for a length of time it became too hot to touch. This represented a hazard both to an operator and additionally posed somewhat of a fire hazard when employed in explosive atmospheres. An event marker in accordance with the preferred form of applicants' invention has been found to operate satisfactorily at less than one watt power dissipation as against five or more watts dissipated by event markers of prior art types.

In the practice of applicants' invention it has been found that the spool 72 may have an overall length of approximately one-half inch, the flange O.D. may be of the order of 15/32 of and inch, the O.D. of the spool about 0.30 inch and the I.D. about one-fourth inch. The solenoid is comprised of approximately 0.12 ounce of No. 36 B&S gauge copper wire wound on the spool to provide a coil having 170 ampere turns. The permanent magnet 76 may be of ALINCO 8 HE about 5/32 of an inch thick and magnetized in a direction so that the opposite faces are of unlike poles and the field strength is approximately 150 gauss. The cover 74 may be of No. 416 stainless steel with a gap of about 5/16 of an inch.

While applicants' invention has been illustrated using specific examples of structure and materials it will be apparent that the structures may take different forms and various materials may be utilized which would be found suitable for the practice of applicants' invention. Additionally, it is believed clear that some features of applicants' invention may be employed without the use of other features within the scope of applicants' claims.

What is claimed is:

1. A graphic recorder having an event marker comprising:
   - a longitudinally fixed guide shaft including ferromagnetic material,
   - a marker assembly having means for supporting a marker and means to support nonmagnetic bearing structure for sliding engagement with said shaft,
   - a coil of wire wound about the axis of said bearing structure to form a solenoid which when energized will produce a magnetic flux which in turn produces magnetic poles on said guide shaft which cause said solenoid and therefore said marker assembly to be drawn toward the longitudinal center of said shaft.

2. A graphic recorder in accordance with claim 1 wherein said guide shaft including ferromagnetic material includes stop structure for limiting the path of travel of said marker assembly, and means biasing said marker assembly toward an element of said stop structure disposed toward an end of said shaft.

3. A graphic recorder according to claim 2 wherein a compression spring is disposed between said marker assembly and one element of said stop structure and biases said marker assembly toward said an-element-of-

said-stop-structure disposed toward an end of said shaft and wherein energization of said solenoid creates sufficient force to overcome that of said spring and effects movement of said marker assembly toward said one element of said stop structure.

4. A graphic recorder according to claim **2** wherein said an-element-of-said-stop-structure is a permanent magnet magnetized so that a face thereof disposed toward said marker assembly is one pole and the face thereof disposed toward the end of said shaft is an opposite pole and said marker assembly carries an amount of ferromagnetic material which is attracted with sufficient force by said permanent magnet when said solenoid is deenergized to draw and hold said marker assembly adjacent said permanent magnet, and energization of said solenoid with the proper polarity creates magnetic flux of sufficient force and in a direction to cause said marker carriage to be repelled by said permanent magnet and simultaneously drawn toward the longitudinal center of said guide shaft and another element of said stop structure.

5. A graphic recorder according to claim **2** wherein said guide shaft of ferromagnetic material has an end portion of weak magnetic material and where the juncture between said ferromagnetic and weak magnetic materials is adjacent said an-element-of-said-stop-structure.

6. A graphic recorder according to claim **2** wherein a permanent magnet disposed near an extremity of said shaft forms a part of said stop structure, a split sleeve of ferromagnetic material substantially surrounds the major portion of said solenoid so that when said solenoid is deenergized said marker assembly is drawn to and held adjacent said permanent magnet due to the attractive force between said split sleeve and said magnet, and when said solenoid is energized by a direct current of proper polarity, a magnetic field is created which opposes that of said permanent magnet so that said marker assembly is repelled by the permanent magnet with sufficient force to move away from said magnet, said field simultaneously producing magnetic poles on said shaft which cause said solenoid and therefore said marker assembly to move away from the end of said shaft and said permanent magnet and toward the longitudinal center of said shaft until movement is arrested by another element of said stop structure.

7. A graphic recorder according to claim **1** wherein said longitudinally fixed guide shaft has an end portion of weak magnetic material.

8. A graphic recorder in accordance with claim **1** wherein said guide shaft comprises two portions of different length, a longer portion which is of ferromagnetic material and a shorter end portion which is of weak magnetic material, and said stop structure and biasing means are disposed so that an end of said solenoid adjacent stop structure toward which said solenoid is biased is disposed substantially at the juncture of said ferromagnetic and weak magnetic materials and with the ferromagnetic material extending through and beyond said solenoid.

9. An event marker assembly for a graphic recorder, said assembly having a marker carriage for supporting a marking device, said carriage being comprised of wall structure of nonmagnetic material, portions of said wall structure projecting to form a pair of spaced-apart ear portions having aligned openings, a spool made of nonmagnetic material, said spool having a boss on the outside of each flange and the dimensions of said spool and its bosses being such that said spool is securely supported in the aligned openings of said ear portions, the internal diameter of said spool forming bearing structure for sliding engagement with a guide shaft, wire wrapped around said spool to form a solenoid which when energized effects movement of said carriage along said shaft in one direction, and a sleeve of ferromagnetic material partially surrounding said solenoid which cooperates with a stationary magnet for effecting movement of said carriage along said shaft in the opposite direction upon deenergization of said solenoid.

10. A marker assembly according to claim **9** wherein a portion of said wall structure defines a cavity for the storage of a supply of ink and further includes means for receiving a snap-in rigid pen capillary extending into said supply of ink.

11. A marker assembly according to claim **10** wherein a portion of said wall structure projects exteriorly of said cavity for engagement with marker lifting structure.

12. A graphic recorder having one or more servo driven marking means and one or more event marking means comprising:

a guide shaft at least the major portion of which is of ferromagnetic material for guiding marking means across a chart,

a servo driven marking means and an event marking means mounted on carriages slideable along said guide shaft,

means disposed with respect to said shaft forming stop structure for the carriage carrying said event marking means,

means disposed with respect to said guide shaft biasing the carriage carrying said event marking means toward an element of said stop structure disposed adjacent an end of said guide shaft, said carriage carrying said event marking means including bearing structure for journaling said carriage on said guide shaft, and

a coil of wire surrounding the axis of said bearing structure to form a solenoid which when energized produces a magnetic flux which in turn produces magnetic poles on said guide shaft which cause said solenoid and therefore said event marker to be moved away from said an-element-of-said-stop-structure and toward the longitudinal center of said guide shaft until movement thereof is arrested by another element of said stop structure.

13. A graphic recorder according to claim **12** wherein said event marking means is disposed with respect to its carriage so that it records on the same time line of a recorder chart as said servo driven marking means.

14. A graphic recorder according to claim **12** including a circuit for energizing said solenoid, said circuit including a source of power, a control switch, and said solenoid in series and a diode in parallel with said solenoid to minimize electrical interference with low level electrical circuits associated with means controlling operation of said servo driven marking means when said solenoid is deenergized.

15. A graphic recorder according to claim **12** including a cross member pivoted to be moved in a path parallel to the longitudinal axis of said guide shaft from a marker lift position to a marker engaged position and each of said servo driven marking means and event

marking means mounted on said guide shaft having a cross-member-engaging-portion disposed with respect to said cross member so that all of said marking means will be simultaneously lifted from and engaged with said chart as said cross member is moved to its marker lift and marker engaged positions regardless of the positions of said marking means across said chart.

* * * * *