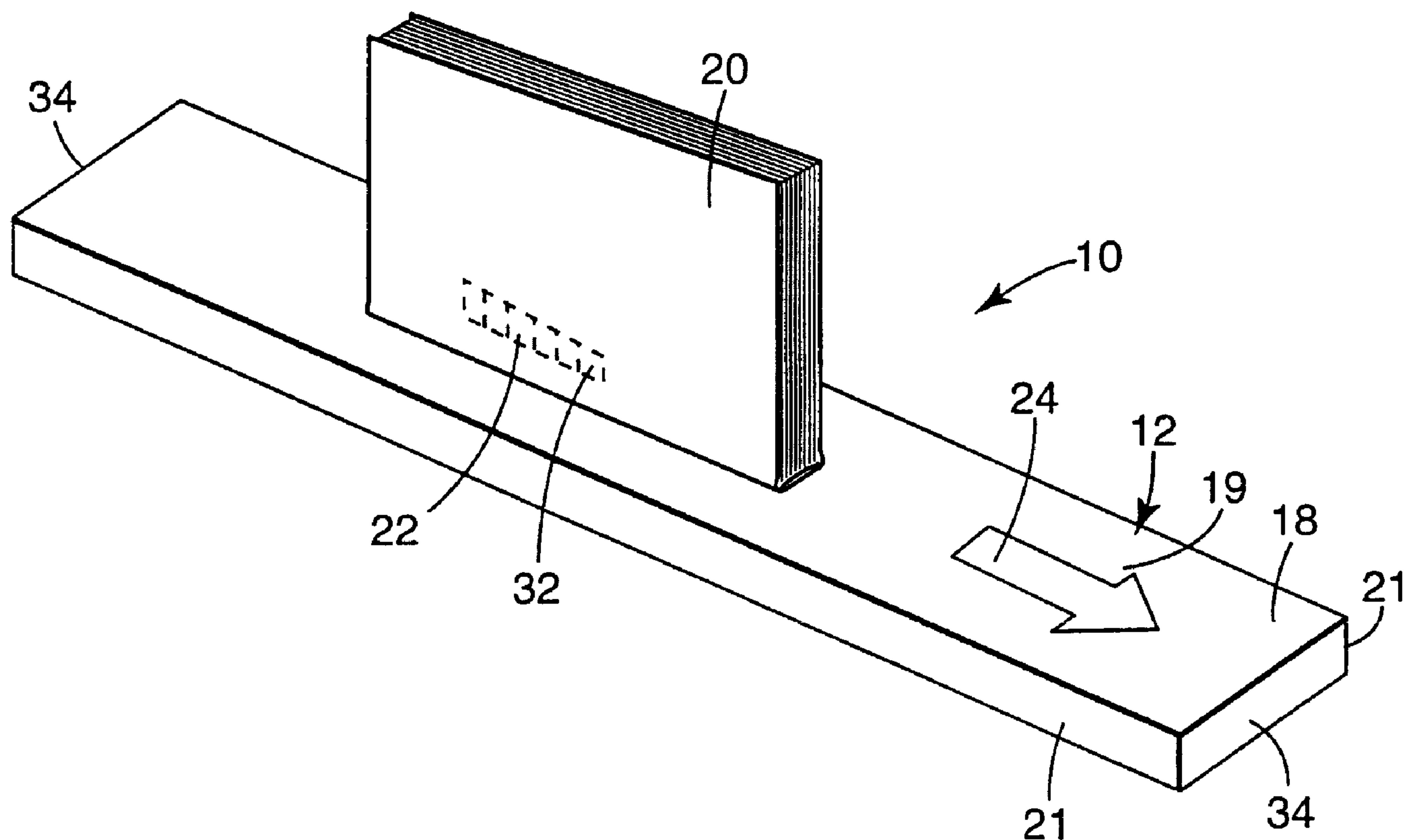




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(54) Title: FAR FIELD MAGNET RESENSITIZER APPARATUS FOR USE WITH ARTICLE SURVEILLANCE SYSTEMS



(57) Abrégé/Abstract:

A demagnetization apparatus for use with magnetically based electronic article surveillance systems having a dual status anti-theft marker containing at least one demagnetizable control element which when demagnetized allows the marker to be detected by the

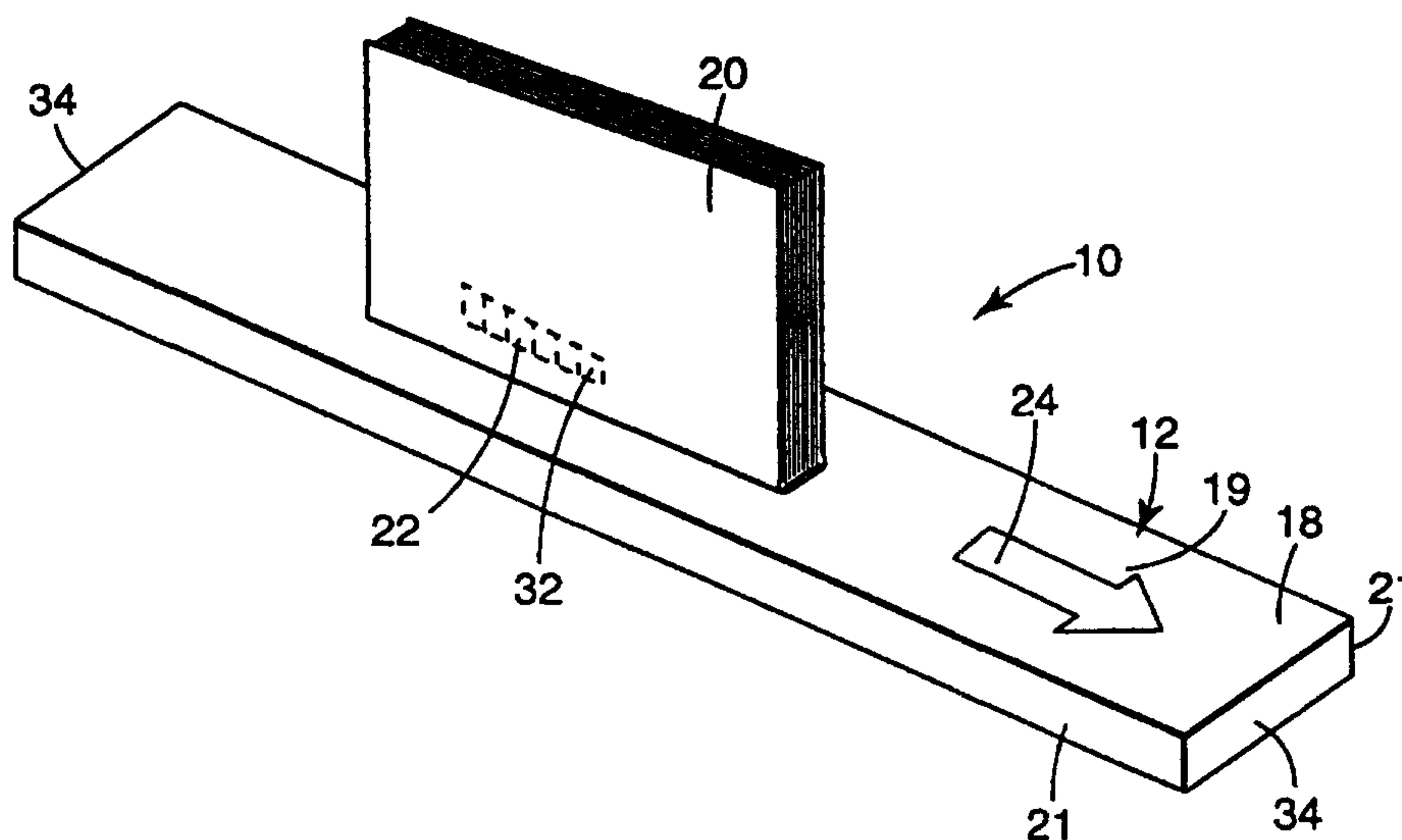
(57) **Abrégé(suite)/Abstract(continued):**

system when the marker is present in an interrogation zone. The apparatus includes an array of magnets contained within a housing which exhibits a succession of fields of alternate polarity and at least a portion of which exhibits exponentially decreasing intensities along a plurality of paths at distances above the working surface of the housing along that portion of the magnet array. The magnet array is configured and arranged such that the external field is sufficient to demagnetize the demagnetizable element of the markers that pass along paths at varying distances from the magnet array.

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(54) Title: FAR FIELD MAGNET RESENSITIZER APPARATUS FOR USE WITH ARTICLE SURVEILLANCE SYSTEMS**(57) Abstract**

A demagnetization apparatus for use with magnetically based electronic article surveillance systems having a dual status anti-theft marker containing at least one demagnetizable control element which when demagnetized allows the marker to be detected by the system when the marker is present in an interrogation zone. The apparatus includes an array of magnets contained within a housing which exhibits a succession of fields of alternate polarity and at least a portion of which exhibits exponentially decreasing intensities along a plurality of paths at distances above the working surface of the housing along that portion of the magnet array. The magnet array is configured and arranged such that the external field is sufficient to demagnetize the demagnetizable element of the markers that pass along paths at varying distances from the magnet array.

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FAR FIELD MAGNET RESENSITIZER APPARATUS FOR USE WITH ARTICLE SURVEILLANCE SYSTEMS

Technical Field

5 The present invention relates to electronic article surveillance (EAS) systems of the type in which a dual status marker, affixed to articles to be protected, causes a detectable signal in response to an alternating magnetic field produced in an interrogation zone. More particularly, the present invention relates to an apparatus for changing the state of such markers.

Background

10 EAS systems of the type described above are described in U.S. Pat. No. 4,689,590 and U.S. Patent No. 4,752,758. With such systems,
15 a dual status marker may comprise a piece of a high permeability, low coercive force magnetic material and at least one permanently magnetizable control element. When the control element is demagnetized, a signal may be produced when the marker is in the zone, and when magnetized, a different signal corresponding to another state of the marker may be produced. These dual status
20 markers may be sensitized (by demagnetizing the high-coercive force control elements thereof) by applying an alternating magnetic field of diminishing amplitude.

 Such a demagnetization operation may be effected through the proper selection and arrangement of a series of permanent magnets in which adjacent magnets are oppositely polarized. By selecting the magnets to be of different
25 strengths and by arranging them in an order ranging from highest to lowest (relative to the direction of travel), the magnetic field will appear to diminish in amplitude when an article having a control element passes over the magnets.

 The above-mentioned references describe an apparatus that creates a magnetic field at or near the working surface on which an article having a marker is placed.
30 One of the primary reasons for the development of the near field resensitizer described in U.S. Patent Nos. 4,689,590 and 4,752,758, was to provide a safe way to resensitize magnetic markers affixed to the cover of a magnetically sensitive media such as audio cassettes or video cassettes without interfering with the signals

on the magnetically sensitive media. These solid state decaying magnetic arrays take advantage of the fact that similar magnets placed close together, with their poles alternately arrayed, tend to have their external fields cancel out when they are measured much beyond a distance of approximately the width of a magnetic pole face. Within about half this distance, the observed magnetic field is almost exclusively the result of the near pole and the magnetic fields from the other magnets can almost be ignored. However, at measured distances from the array, the measured field of the near magnet starts to be affected by the other magnets in the array. At a distance about two to three pole faces above the magnetic array, all the external magnetic vectors start to cancel each other out and the resulting external field is very low. As a result, there is little residual external magnetic field above the magnet array to cause harm to magnetic media.

While a near field array of permanent magnets is useful in demagnetizing control elements contained in anti-theft markers affixed to prerecorded magnetic tapes without affecting the prerecorded signals on such tapes, the near field array is not as useful on articles in which the markers cannot be positioned sufficiently close to the surface of the magnet array. As mentioned, at appreciable distances away from the near field array, the external field is very low. Therefore, the near field array may be ineffective in resensitizing markers at increased distances from the array. This may occur, for example with articles in which the marker is embedded within the article away from the surface such as in the spine of a book. Moreover, the distance from the array of a marker on articles such as books may vary depending on the size or shape of the article. Since optimal ring-down occurs when the alternating field decreases in an exponential envelope, it is necessary for the magnetic marker to experience an exponential decaying magnetic field as it is moved past the array regardless of its distance from the array. However, at distances above a given magnet in the array there is an appreciable contribution from the other magnets in the array, and this contribution varies depending on the distance from the given magnet to the other array magnets and the distance the marker is above the given magnet. It can be seen then that there exists a need for a device that provides for sensitizing EAS markers on articles when the location of the marker on the article, and hence the distance of the marker from a sensitizing apparatus, is unknown.

The present invention provides solutions to these and other problems, and offers other advantages over the prior art designs.

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Summary of the Invention

According to one broad aspect of the present invention, there is provided an arrangement which in movement relative to an article, having affixed thereto a dual status electronic article surveillance marker including at least one control element, demagnetizes the control element to change the status of the marker, the arrangement comprising: a housing having a working surface; and an array of magnets coupled to the housing, wherein the array defines a plane along the surface of the magnets, and wherein the array produces an alternating magnetic field having, after a most intense peak, a substantially constant percentage decrease with each field reversal along a plurality of substantially parallel paths at different distances from the working surface.

According to another broad aspect of the present invention, there is provided an apparatus which in movement relative to an article, having affixed thereto a dual status electronic article surveillance marker including at least one control element, demagnetizes the control element to change the status of the marker, the apparatus comprising: (a) a housing having a working surface; and (b) an array of magnets provided at a uniform distance from the working surface, wherein the array exhibits an alternating magnetic field having, after a most intense peak, a substantially constant percentage decrease with each field reversal along the working surface.

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In some embodiments, the apparatus provides a magnet array that produces an alternating magnetic field optimized to decrease in intensity with every field reversal inside an exponential envelope, that is capable of demagnetizing high-coercive force control elements of a marker along paths at varying distances from the magnet array. In addition, the demagnetization apparatus of the present invention requires no power source, sends out no possibly harmful AC fields, and performs without dependence on the speed with which the marker is moved relative to the apparatus.

In some embodiments, the apparatus is adapted for use with an electronic article surveillance (EAS) system for detecting a sensitized dual status anti-theft marker secured to an article. The apparatus may be adapted for use with books or other articles to which a marker is affixed but the distance of the marker from the surface of the article cannot be predicted. The marker in such a system includes a piece of low coercive force, high-permeability ferromagnetic material and at least one control element of a permanently magnetizable high coercive force material positioned proximate to the first material. Such an element, when demagnetized, results in the marker being in a first state, such as, for example, a sensitized state in which the marker may be detected when it is in the interrogation zone. Conversely, when the control element is magnetized, the marker is in a second state, such as, for example, a desensitized state in which the marker is not detected when it is in the zone.

In some embodiments, the apparatus comprises a housing having a working surface relative to which the article may be moved and an array of magnets associated with the housing. The magnets within the array are sized and positioned relative to other magnets in the array so as to exhibit along a plurality of paths at varying distances above the working surface of the housing a succession of fields of alternate polarity whose intensities decrease upon each field reversal within an exponential envelope. Each magnet extends substantially across the width of the housing and the succession of magnets extend along the length of the housing. Thus, movement of the article relative to the working surface from a position adjacent the most intense field past each successively weaker field of opposite polarity will expose the marker affixed thereto to fields of alternate polarities and exponentially decreasing intensities to substantially demagnetize the control element of the marker. This will occur

within a range of distances above the working surface so as to sensitize the marker regardless of the location of the marker on the article.

Brief Description of the Drawings

- 5 The various objects, features, and advantages of the present deactivating device will be understood upon reading and understanding the following detailed description and accompanying drawings, in which:
- FIG. 1 is a perspective view of one embodiment of the demagnetization apparatus of the present invention;
- 10 FIG. 2 is an enlarged top view of FIG. 1, with the cover partially removed;
- FIG. 3 is a cross sectional view of FIG. 2, taken along the lines 2-2;
- FIG. 4 is a graph representing the field strength and polarity along a path at a distance of 0.32 cm (0.125 inches) above the surface of a magnet array such as in FIGS. 1-2;
- FIG. 5 is a graph representing the field strength and polarity along a path at a distance of 0.57 cm (0.225 inches) above the surface of a magnet array such as in FIGS. 1-2;
- 15 FIG. 6 is a graph representing the field strength and polarity along a path at a distance of 0.83 cm (0.325 inches) above the surface of a magnet array such as in FIGS. 1-2;
- FIG. 7 is a graph representing the field strength and polarity along a path at a distance of 1.08 cm (0.425 inches) above the surface of a magnet array such as in FIGS. 1-2;
- 20 FIG. 8 is a graph representing the field strength and polarity along a path at a distance of 1.59 cm (0.625 inches) above the surface of a magnet array such as in FIGS. 1-2;
- FIG. 9 is a semi-log graph illustrating field strength along portions of the paths in FIGS. 4-8 for the demagnetization apparatus of the present invention; and
- FIG. 10 is a schematic representation of an enlarged section of the embodiment of the magnetic array of FIG. 3, and the alternating magnetic field produced by each of the magnets in the array.
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Detailed Description of the Drawings

- As shown in FIG. 1, the demagnetization apparatus of the present invention may be in the form of a counter top apparatus 10. The apparatus could also take other forms as will be recognized by those of skill in the art. The counter top apparatus 10 includes a housing 12 and an array of magnets (see FIGS. 2 and 3) mounted within the housing 12.
- 30

The housing 12 includes a non-magnetic cover plate 18 which both covers and protects the array of magnets. In addition, the cover plate 18 provides a working surface 19 relative to which an article 20 having a marker 22 affixed thereto may be moved during use of the apparatus. Such a cover plate 18 may comprise a strip of non-magnetic stainless steel having a thickness in the range of 20 mils (0.50 mm). The use of a metallic cover plate 18 is further desired because such a surface resists wear from scratching or chipping as may otherwise occur with cover plates having a polymeric or painted surface, and it thereby remains aesthetically acceptable even over many cycles of use. While the apparatus 10 may be used with the working surface 19 established by the cover plate 18 in a horizontal position, such that an article 20 may be moved across the horizontal surface, the apparatus may also be positioned to have the working surface 19 vertical.

The housing 12 further includes sidewalls 21 and ends 34 that attach to the sidewalls 21 with, for example, a bolt or screw 35 such as shown in FIGS. 2 and 3. In one embodiment, the sidewalls 21 are aluminum rails having dimension of 0.95 cm x 3.81 cm with a length of 63.98 cm (0.375 x 1.5 inches with a length of 25.1875 inches). The portions of the housing 12 are also preferably constructed of non-magnetic materials. Also, beveled faces (not shown) may be provided on the housing 12 to carry appropriate legends, manufacturer identification, instructions, and the like.

In using the apparatus of FIG. 1, it will be recognized that the article 20 is to be moved in the direction shown by arrow 24, thus causing the marker 22 affixed to one surface of the article to be moved so that the marker 22 is passed over the array of magnets positioned directly beneath the cover plate 18. Thus, for example, if the article 20 is a book such as illustrated in FIG. 1, the marker 22 could be affixed within the spine, and the book held so as to be positioned on the cover plate 18 and passed along the working surface 19 in the direction of the arrow 24. The demagnetization of the control element 32 is effected upon exposure to the fields produced by the array of magnets when the control element 32 is brought into close proximity with the magnetic fields associated with the magnet array above the working surface 19.

The marker 22 is typically constructed of a strip of a high permeability, low coercive force magnetic material such as a permalloy, certain amorphous alloys, or the like as disclosed, for example, in U.S. Pat. No. 3,790,945 (Fearon). The marker 22 is further provided with at least one control element 32 of high coercive force magnetizable material as

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disclosed, for example, in U.S. Pat. No. 3,747,086 (Peterson). The control element 32 is typically formed of a material such as vicalloy, magnetic stainless steel or the like, having a predetermined value of coercive force in the range of 50 to 240 oersteds. When such an element 32 is magnetized, it prevents the marker 22 from being detected by the system when the marker 22 is present in the interrogation zone. Further examples of dual status markers for use with electromagnetic article surveillance systems are disclosed in U.S. Pat. No. 5,432,499 (Montean), U.S. Pat. No. 5,331,313 (Koning), U.S. Pat. No. 5,083,112 (Piotrowski), U.S. Pat. No. 4,967,185 (Montean), U.S. Pat. No. 4,884,063 (Church), U.S. Pat. No. 4,825,197 (Church), U.S. Pat. No. 4,745,401 (Montean), and U.S. Pat. No. 4,710,754 (Montean).

The details of the magnet array of the apparatus in FIG. 1 are shown in FIGS. 2 and 3. In the disclosed embodiment, the array includes thirty discrete magnets 100. As shown, grooves are formed within the sidewalls 21. A groove formed within the first sidewall has a corresponding groove directly across on the other sidewall 21. Each of the magnets 100 in the magnet array is positioned within the housing 12 by sliding the magnet 100 within a pair of the corresponding grooves within the sidewalls 21. The magnets 100 are to be secured in position within the grooves with suitable epoxy, or alternatively, mechanical fasteners. As seen in FIG. 3, each of the magnets extend within the grooves into the housing 12 until the top face of the magnet 100 is approximately level with the top of the sidewalls 21. When the cover plate 18 is positioned on the housing 12 to rest on the sidewalls 21, the face of the magnet 100 contacts or is positioned directly beneath the cover plate 18. As such, the faces of the magnets 100 in the array are positioned at approximately the same distance relative to the marker 22 on an article 20 placed on the cover plate 18 as the marker 22 is from the working surface defined by the top surface of the cover plate 18.

The faces of the magnets 100 directed toward the cover plate 18 are poles that create a magnetic field extending upward from the cover plate 18. Each of the magnets are sized and positioned relative to adjacent magnets so as to create along multiple paths, within a range above the cover plate 18, a magnetic field of alternating polarity and of suitable intensity that decreases within an exponential envelope from one end of the elongated magnetic array to the other. One of skill in the art will appreciate that such fields may be created along a plurality of paths at varying distances above the cover plate 18 by methods which include providing appropriate shielding to alter the effective strength of each magnet

100 as well as adjusting positions of the magnets 100 relative to the cover plate 18 and to the other magnets 100 within the magnet array. In the embodiment shown in FIGS. 2 and 3, each of the magnets (and hence the poles that are defined by the face of the magnet contacting the cover plate) extends across the width of the housing, and the succession of
5 thirty magnets in the magnet array extends along the length of the housing 12. Although the magnets 100 are shown as generally decreasing in size, this is representational of decreasing strength only and not necessarily of actual physical size. The important factor regarding the strength of the magnets is that the strength of each magnet is preferably determined so that the fields created along multiple paths above and parallel to the working surface decrease
10 within an exponential envelope along the length of the magnet array. For the counter top apparatus 10 of FIG. 1, the field produced along the paths above the cover plate 18 decreases within an exponential envelope in the direction of the arrow 24.

The magnets 100 within the magnet array may be made of any suitable magnetic materials including, but not limited to, any combination of the following: (1) an
15 injection molded permanent magnet material, such as type B-1060 "Plastiform" Brand sold by Arnold Company of Norfolk, Nebraska, which is magnetized after molding and subsequently arranged with appropriately; (2) a sheet material magnetized with alternating poles, such as type B-1013 "Plastiform" Brand, type 2002-B "Plastiform" Brand, or type 1030-B "Plastiform" Brand, all sold by Arnold Company of Norfolk, Nebraska; or (3) a
20 machineable metallic material such as Nd 35 or Nd 40 or other NdFeB alloy such as sold under the brand name Magnaquench by MagStar Technologies, St. Anthony, Minnesota. Other appropriate materials will also be recognized by those of skill in the art.

FIGS. 4 - 8 illustrate alternating magnetic fields of exponentially decreasing intensity along paths within the range of 0.32 to 1.59 cm (0.125 inches to 0.625 inches)
25 above the working surface that are produced by one embodiment of a magnet array set forth below in Table 1. FIG. 4 shows the alternating magnetic field along a path at a distance of 0.32 cm (0.125 inches) above the surface of the magnet array. FIG. 5 shows the alternating magnetic field along a path at a distance of 0.57 cm (0.225 inches) above the surface of the magnet array. FIG. 6 shows the alternating magnetic field along a path at a distance of 0.83
30 cm (0.325 inches) above the surface of the magnet array. FIG. 7 shows the alternating magnetic field along a path at a distance of 1.08 cm (0.425 inches) above the surface of the magnet array. FIG. 8 shows the alternating magnetic field along a path at a distance of 1.59

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cm (0.625 inches) above the surface of the magnet array. The range of distances in FIGS. 4-8 represents the range of distances for which a marker on, for example, a book will likely be positioned from the cover of the apparatus of FIG. 1. The corresponding peaks and valleys in FIGS. 4 - 8 represent the field intensity at that location along the path.

5 In order to demagnetize a marker, the marker should pass along a path that has a field strength that decreases from approximately 300 gauss to 70 gauss. Anything greater than 300 gauss will typically completely magnetize the magnetic control elements of the marker in question, and anything less than 70 gauss will typically have no effect on the magnetic control elements. Referring again to FIGS. 4-8, it can be seen that a magnetic marker
10 passing along the entire magnet array will experience this correct exponential decaying field regardless of a distance from the array. However, it can be seen that the location within the array in which the marker passes through the decaying range of 300 gauss to 70 gauss differs depending on the distance of the marker from the surface of the magnet array. For example, as shown in the semi-log plot in FIG. 9, along a path 0.32 cm (0.125 inches) above the
15 magnet array a marker passes through this range in the disclosed embodiment magnet array between the nineteenth and thirtieth magnets in the magnet array, whereas along a path 1.59 cm (0.625 inches) above the magnet array a marker would pass through this range when passing between the second and twelfth magnets of the magnet array. Therefore, because the location of a marker on an article is unknown, it is important that a user who is
20 demagnetizing a marker on an article passes the article along the entire length of the cover plate 18 of the apparatus.

Providing an exponentially decaying field along paths at varying distances above the magnet array is necessary because there is no way to predict the distance or orientation of the magnetic marker in, for example, a book or similar device as it is used in
25 this invention. As shown, this invention will sensitize a magnet marker at any distance from 0.32 to 1.59 cm (0.125 to 0.625 inches) above the surface of the magnet array. It can be appreciated by those of skill in the art that the size, strength and positioning of the magnets within the array can be altered to increase or decrease that range. Such alterations are within the scope of this invention.

30 The magnetic field intensity and polarity at a given position P along a path above the surface of the magnet array is governed by the algebraic sum of the intensity and polarity of each magnet reduced appropriately according to its distance from the position P.

Thus, the field contribution of any given magnet is affected by the field contribution of its adjacent magnets, its next nearest magnets, and so on. The magnets positioned at each end of the magnet array, however, are adjacent to only one other magnet and thus may have an undesirably large contribution to the magnetic field along the path in the region above these end magnets. For this reason, the end magnets must be carefully selected and adjusted so that their contribution to the field intensity along the path is not so large so as to deviate from the exponential envelope of the entire magnet array. It will be appreciated by one of skill in the art that the selection and adjustment of the end magnets may be properly affected by partial shielding of the end magnets, adjusting the spacing of the end magnets relative to the working surface and to the other magnets, adjusting the magnet strength by material or size of the magnet, by adequately trimming the end magnets, or by offsetting the end magnets relative to the working surface.

It is preferred that the most intense peak or valley seen by the control element is strong enough to initiate the demagnetization process by ensuring that all magnetic domains in the control element are oriented in one direction parallel with the initial field. In order to initiate the demagnetization process, it has been found that the most intense pole is preferably at least approximately one and one half times the predetermined value of coercive force of the control elements. Subsequent to the most intense pole, each field reversal ends preferably in a peak or valley whose intensity is decreased by approximately the same percentage from the previous peak or valley. It has been found that demagnetization will occur if on the average the field intensity associated with each successive pole changes by 5 to 20 percent between any two adjacent poles. Preferably, the field intensity associated with each successive pole changes by approximately 15 percent between any two adjacent poles. It is also preferred that the last peak or valley seen by the control element is weaker than all previous poles so that the control element is not left with an undesirable net magnetization. Thus, as illustrated by the final peak shown in each of FIGS. 4-8, the final pole is preferably chosen so that the field falls off to zero in concert with the exponential envelope.

When an alternating magnetic field decreases within an exponential envelope, the percent decrease between any two adjacent magnets remains constant. The rapidity with which the field decreases in such a magnetic circuit may be described as its Q value, defined by:

$$Q = -n\pi/\ln(H_o/H_n)$$

wherein

H_0 = field at the working distance associated with any given pole; and

H_n = field at the working distance associated with a pole located n poles away from
5 the given pole.

A magnetic section with an exponentially decreasing field along the working distance is thus defined by a constant Q value. An alternating field that decreased approximately 15 percent between adjacent poles would thus have a Q value of approximately 9.5.

10 A series of poles establishing a magnetic field with a constant Q value ensures that a control element moved relative to the magnetic field in the direction of decreasing field strength will be incrementally demagnetized, undergoing a net demagnetization by the same percent with each field reversal. A magnetic field that does not decrease exponentially will necessarily have regions where the incremental demagnetization
15 occurs too rapidly, too slowly, or both, resulting in the control element not being completely demagnetized or an apparatus that is larger than necessary to achieve full demagnetization.

FIG. 9 schematically illustrates the decrease in peak to peak field intensity with distance along portions of the paths in FIGS. 4-8 for the demagnetization apparatus of the present invention. FIG. 9 represents a semi-log plot of the envelope in which the
20 alternating fields decrease in the apparatus of the present invention along several paths at distances between .125 and .625 inches above the surface of the magnet array. Each of lines 90, 88, 86, 84 and 82 in FIG. 9 corresponds to the paths in FIGS. 4-8, respectively. As can be seen, an exponentially decreasing alternating magnetic field such as embodied in the present invention yields straight lines for each of the paths on the semi-log plot, thus denoting
25 a constant Q value and a constant percent decrease along each of the paths. When a demagnetization apparatus comprises a magnetic field that deviates from constant percentage decrease, there will be regions in which the magnetic field decreases too rapidly, thus risking a residual magnetization of the control element, and there will be regions in which the magnetic field decreases too slowly, thus requiring a longer magnetic section than would be
30 required for an alternating field that decreases by a constant percentage with each field reversal.

One embodiment of the present invention includes a calibrated array of discrete magnets each comprising a length of permanently magnetized material sandwiched between two flux collectors. In this embodiment, the magnetic polarity of each discrete magnet alternates from magnet to magnet so that the line drawn from the north pole to the south pole for each discrete magnet lies along the length of the magnet array. The array is preferably calibrated by choosing the magnet material for each discrete magnet and adjusting the size of the magnet so that when it is positioned in its proper place in the array the magnetic array will display an alternating field of exponentially decreasing intensities. FIG. 10 schematically illustrates from a cross sectional view the preferred construction of each discrete magnet 108 in the magnet array of the present invention. Each magnet 108 is constructed from a length of permanently magnetized material 106 and positioned so that its magnetic pole is aligned along the length of the array as indicated by arrow 104. The size of each permanent magnet 106 and the material from which it is made is chosen so that the magnetic field produced along multiple paths above the surface of the array for the entire array alternates and decreases at a constant percentage with each field reversal. The flux collectors 102 that sandwich each permanent magnet 106 gather the flux lines produced by the permanent magnet so that the field on the path above the surface of the array above each magnet is parallel to the particular path. These flux collectors 102 are preferably made from a mild steel. While the detailed magnetic properties of the flux collectors 102 is not critical, the flux collectors 102 should preferably be designed to absorb at least as much of the magnetic flux produced by its associated permanent magnet.

The discrete magnets 108 of the magnetic array of the present invention are preferably arranged in one of two ways in order to generate a series of alternating poles, as illustrated in FIG. 10. The upper series of magnets 117 shows a section of an array in which each magnet 106 has a polarity 104 that is counter parallel (parallel and in the opposite direction) to the polarities of its adjacent magnets. Such an arrangement produces an alternating magnetic field 116 that successively reaches a maximum positive intensity and a maximum negative intensity directly above the center of each magnet 106 and reaches zero intensity above the midpoint between two adjacent magnets as shown by waveform 116. In such an arrangement, the number of discrete magnets 108 in the array equals the total number of field maxima and minima. The arrangement of the polarities of the upper series of magnets 117 is the arrangement used in the exemplary embodiment magnet array in Table 1.

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The lower series of magnets 115 shows a section of an array in which each magnet 106 has a polarity 104 that is parallel and in the same direction to the polarity of its adjacent magnet. Such an arrangement produces flux lines running from north to south for each individual magnet 106, but it also creates induced poles 105 that produce flux lines running in the opposite direction between magnets from the north of one magnet to the south of the adjacent magnet. In such a manner, an alternating magnetic field 114 is produced that successively reaches a maximum positive intensity directly above each magnet, and a maximum negative intensity above the midpoint between adjacent magnets. In this arrangement, there are twice as many total maxima and minima as there are discrete magnets 108 in the array.

The two arrays 117 and 115 both create alternating magnetic fields, but with different periodicities. FIG. 10 illustrates that between the points 110 and 112 the field produced by array 117 has two field reversals whereas the field produced by the array 115 has four field reversals and each array uses the same number of magnets 106. Thus, half as many magnets are required when using the principle behind array 115 to design a magnet array to achieve the same number of field reversals as with array 117. This may be important when the size of the array is important. By fabricating an elongated magnetic section using a magnet array such as array 115, a much shorter magnetic section will be attained so that a housing with much smaller dimensions can be used.

In addition to having the advantages of more reliable demagnetization performance and smaller size of the magnet array, the performance of the demagnetization apparatus of the present invention is not speed dependent. The demagnetization of the control element 32 does not depend on the speed with which the control element 32 is moved relative to the magnet array because the control element 32 will experience an alternating magnetic field that decreases by a constant percentage with each field reversal without regard to the rate of movement. Thus, the only limitation on the speed with which the control element 32 may be moved relative to the magnet array is determined by the response rate of the magnetic domains of the control element material. However, typical rates of movement during human usage of the demagnetization apparatus of the present invention are in the range of 400 to 700 Hz, which is well below the rate limitation due to magnetic domain response times to magnetic fields.

As mentioned, one exemplary preferred embodiment configuration of the magnet array with respect to material, length, width, thickness, and orientation of each permanent magnet 106, the width of the flux collectors 102, the distance between adjacent magnets and the total number of magnets within the array is tabulated in Table 1. The magnet orientation data in Table 1 are represented by arrows which indicate the north to south orientation of each magnet. It can be appreciated that other embodiments which achieve the objectives of this invention are within the scope of this invention.

Table 1

magnet #	magnet material	magnet orientat'n	Magnet Length (cm)	Magnet Width (cm)	Magnet Height (cm)	Flux collector width (cm)	Distance from previous mag't (cm)
1	Nd 35		10.16	0.274	1.27	0.152	-
2	Nd 35		10.16	0.475	1.27	0.152	2.54
3	Nd 35		10.16	0.419	1.27	0.152	2.54
4	Nd 35		10.16	0.356	1.27	0.152	2.54
5	Nd 35		10.16	0.404	0.841	0.152	2.54
6	Nd 35		10.16	0.318	0.945	0.152	2.54
7	2002B Arnold Plastiform		10.16	0.582	1.27	0.152	2.54
8	2002B Arnold Plastiform		10.16	0.516	1.27	0.152	2.54
9	2002B Arnold Plastiform		10.16	0.434	1.27	0.152	2.54
10	2002B Arnold Plastiform		10.16	0.371	1.27	0.152	2.54
11	2002B Arnold Plastiform		10.16	0.328	1.27	0.152	2.54
12	2002B Arnold Plastiform		10.16	0.318	0.945	0.152	2.54
13	2002B Arnold Plastiform		10.16	0.318	0.737	0.152	2.54
14	2002B Arnold Plastiform		10.16	0.318	0.594	0.122	2.54
15	2002B Arnold Plastiform		10.16	0.318	0.465	0.122	2.54
16	2002B Arnold Plastiform		10.16	0.318	0.366	0.122	2.54
17	2002B Arnold Plastiform		10.16	0.318	0.559	0.122	2.54
18	B1030 Arnold Plastiform		10.16	0.318	0.790	0.122	2.54
19	B1030 Arnold Plastiform		10.16	0.318	0.673	0.122	2.54
20	B1030 Arnold Plastiform		10.16	0.335	0.467	0.122	2.54
21	B1030 Arnold Plastiform		10.16	0.229	0.570	0.122	2.54
22	B1030 Arnold Plastiform		10.16	0.229	0.401	0.122	2.54
23	B1030 Arnold Plastiform		10.16	0.229	0.310	0.122	1.27
24	B1030 Arnold Plastiform		10.16	0.229	0.259	0.122	1.27
25	B1030 Arnold Plastiform		10.16	0.152	0.318	0.122	1.27
26	B1030 Arnold Plastiform		10.16	0.152	2.489	0.122	1.27
27	B1030 Arnold Plastiform		10.16	0.152	1.905	0.122	1.27
28	B1030 Arnold Plastiform		10.16	0.076	0.455	0.122	1.27
29	B1030 Arnold Plastiform		10.16	0.076	0.310	0.122	1.27
30	B1030 Arnold Plastiform		10.16	0.076	0.239	0.122	1.27

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CLAIMS:

1. An arrangement which in movement relative to an article, having affixed thereto a dual status electronic article surveillance marker including at least one control
5 element, demagnetizes the control element to change the status of the marker, the arrangement comprising:

a housing having a working surface; and

an array of magnets coupled to the housing,
wherein the array defines a plane along the surface of the
10 magnets, and wherein the array produces an alternating magnetic field having, after a most intense peak, a substantially constant percentage decrease with each field reversal along a plurality of substantially parallel paths at different distances from the working surface.
- 15 2. The arrangement according to claim 1, further comprising a cover plate positioned over the array, wherein the cover plate has the working surface substantially parallel to the plane.
3. The arrangement according to claim 1 or 2, wherein
20 the substantially constant percentage decrease along each of the plurality of paths is about 15 percent.
4. The arrangement according to claim 2 or 3, wherein the magnets are discrete pieces of permanent magnetic material, and wherein each of the discrete pieces are sized
25 and positioned relative to adjacent magnets to produce the alternating magnetic field having the substantially constant percentage decrease.
5. The arrangement according to claim 4, wherein the discrete pieces of permanent magnetic material are aligned

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such that a line drawn from the north pole to the south pole of each piece lies parallel to the working surface.

6. The arrangement according to any one of claims 1 to 5, wherein each of the plurality of paths are at a distance of less than 1.6 cm from the plane of the array.

7. The arrangement according to claim 5, wherein at least one of said discrete pieces of permanent magnetic material comprises an injection molded magnet material.

8. The arrangement according to claim 5, wherein at least one of said discrete pieces of permanent magnetic material comprises a NdFeB alloy.

9. The arrangement according to any one of claims 5, 7 and 8, further comprising at least one flux collector, positioned with respect to an associated discrete piece of permanent magnetic material such that flux lines produced by the associated discrete piece of magnetic material are parallel with the working surface at the working surface.

10. The arrangement according to claim 9, wherein at least one of said flux collectors is affixed to the associated discrete piece of permanent magnetic material.

11. An apparatus which in movement relative to an article, having affixed thereto a dual status electronic article surveillance marker including at least one control element, demagnetizes the control element to change the status of the marker, the apparatus comprising:

(a) a housing having a working surface; and

(b) an array of magnets provided at a uniform distance from the working surface, wherein the array

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exhibits an alternating magnetic field having, after a most intense peak, a substantially constant percentage decrease with each field reversal along the working surface.

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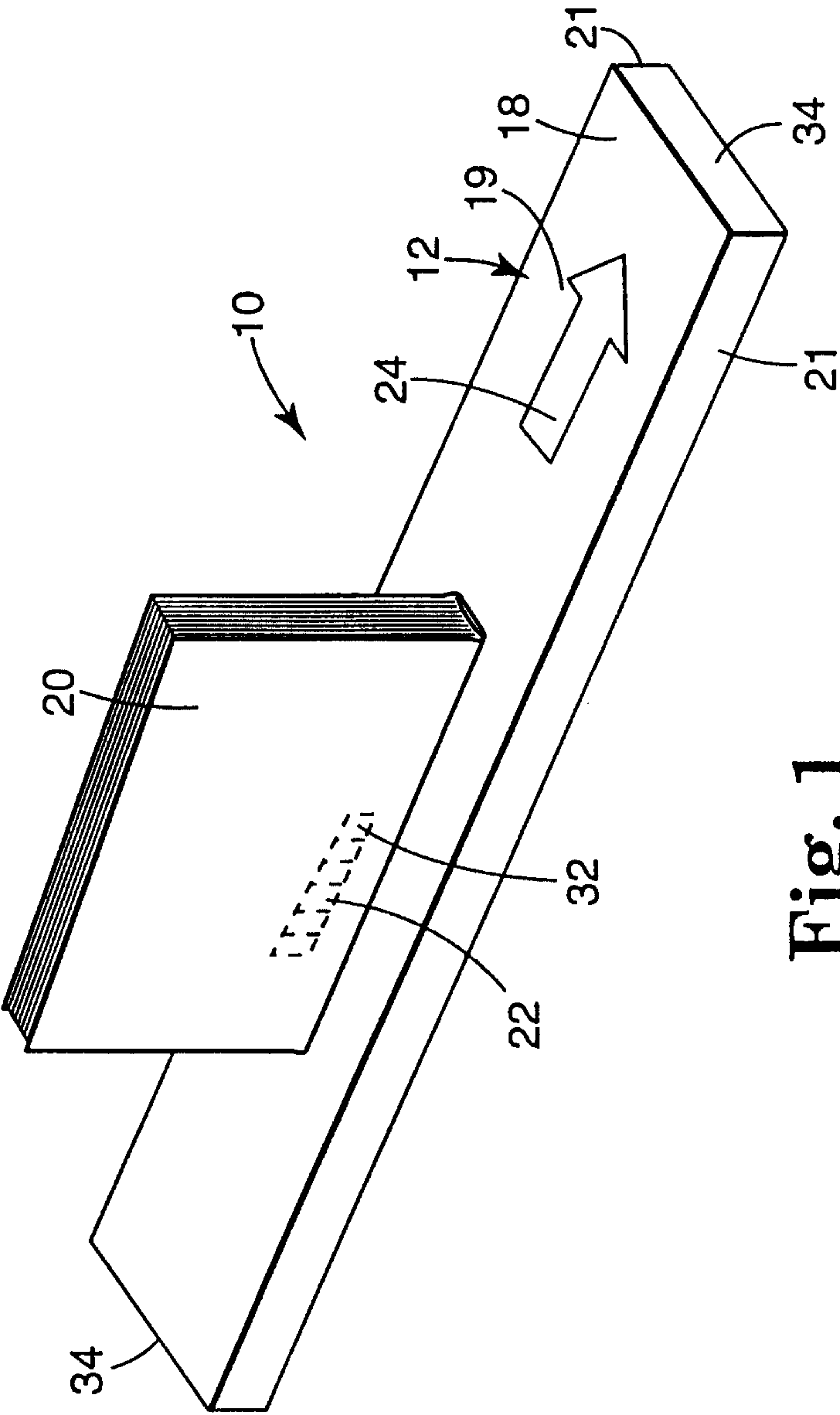


Fig. 1

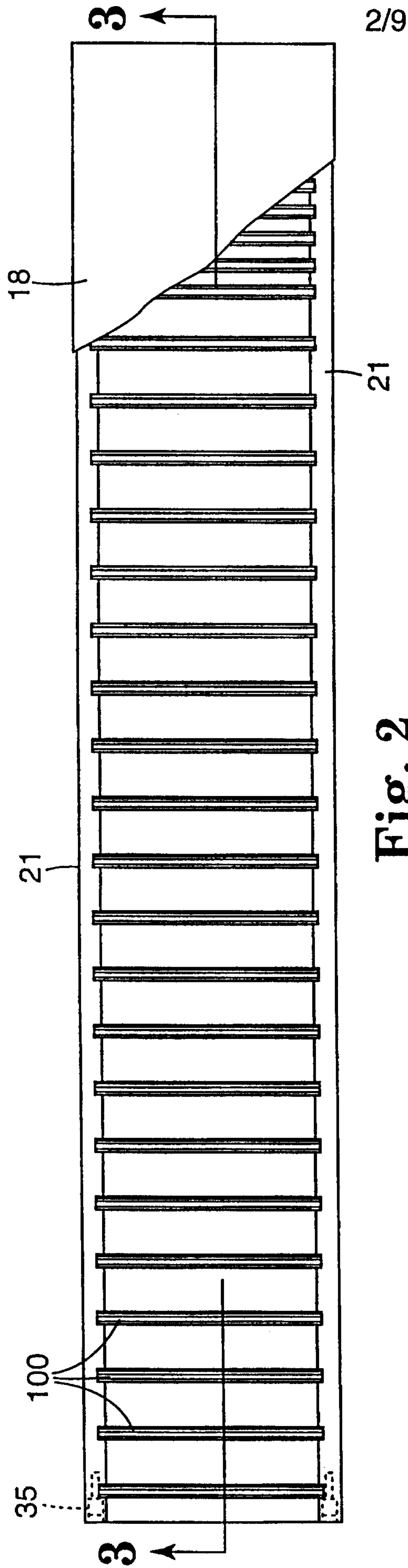


Fig. 2

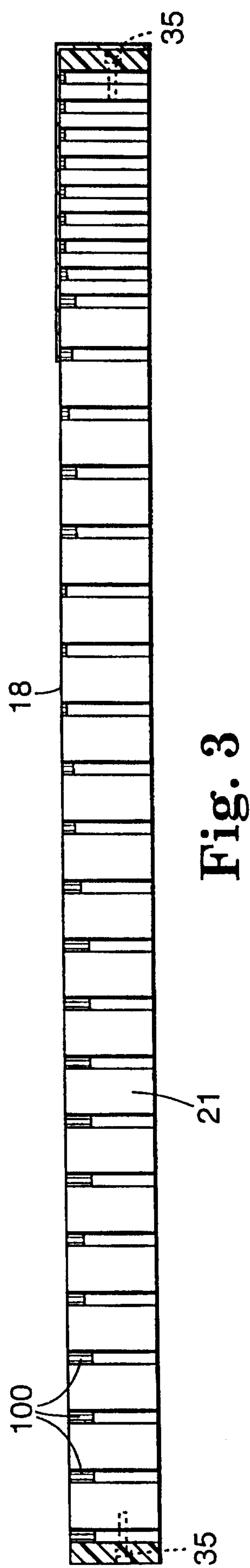
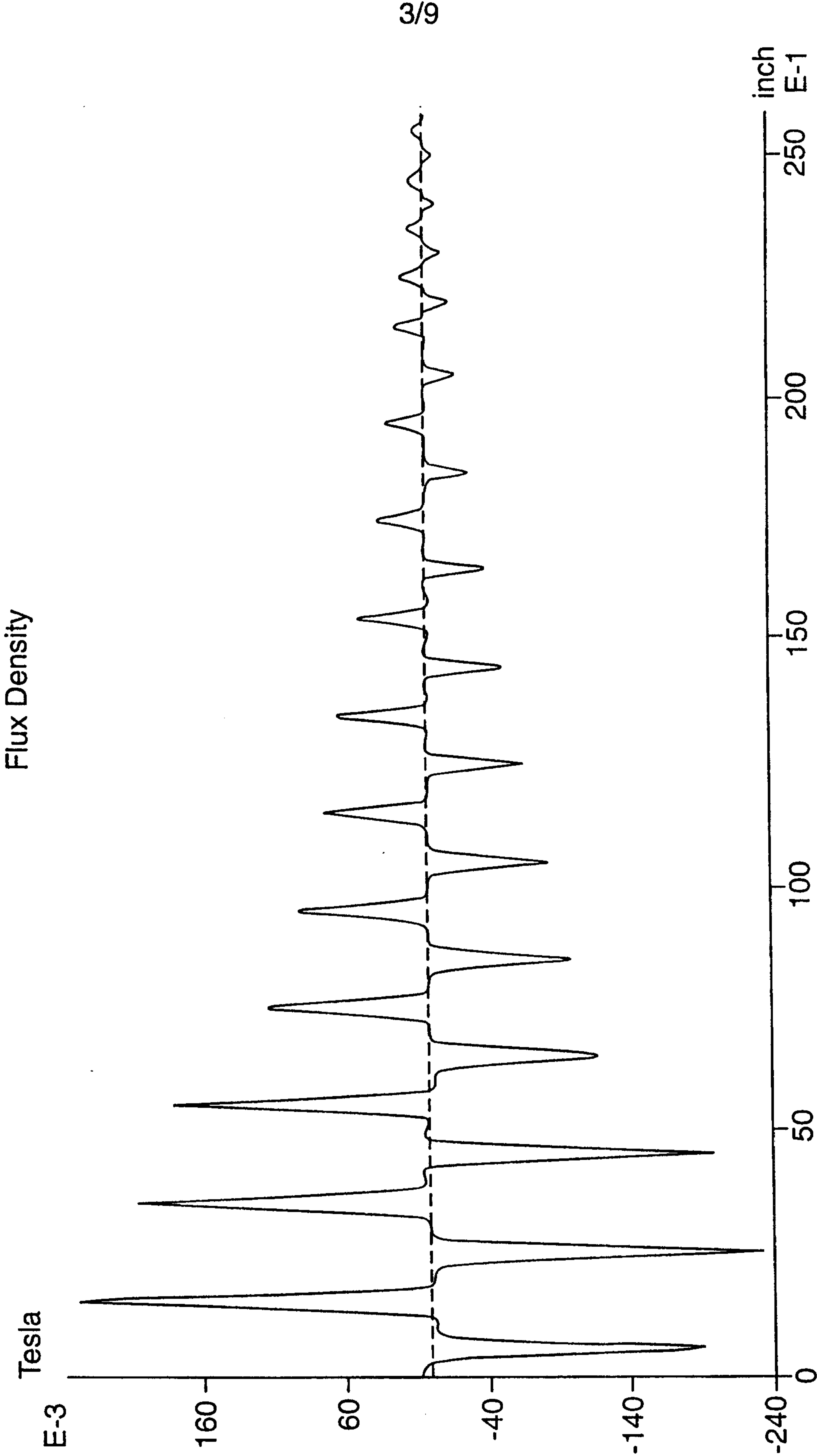
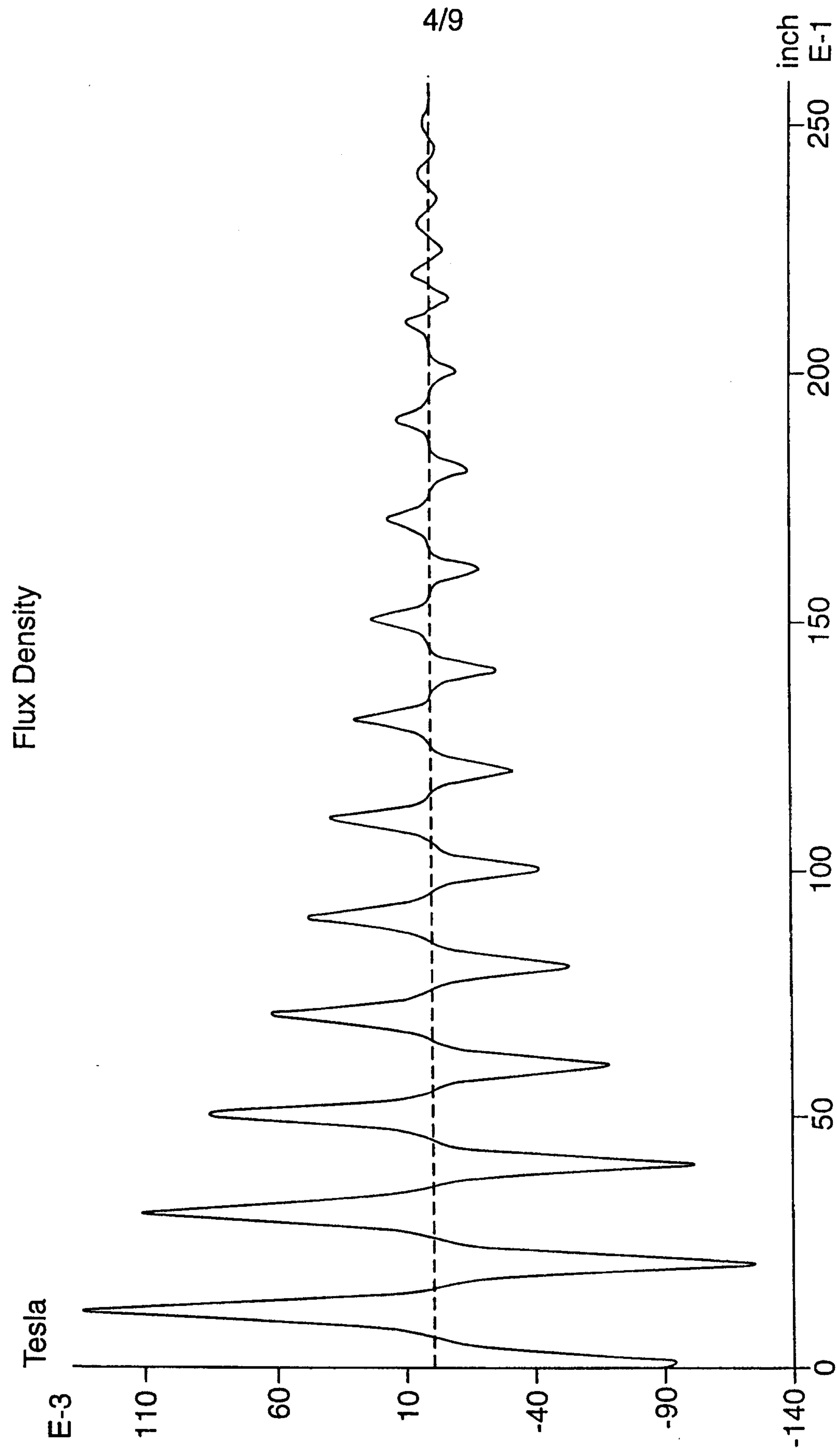


Fig. 3



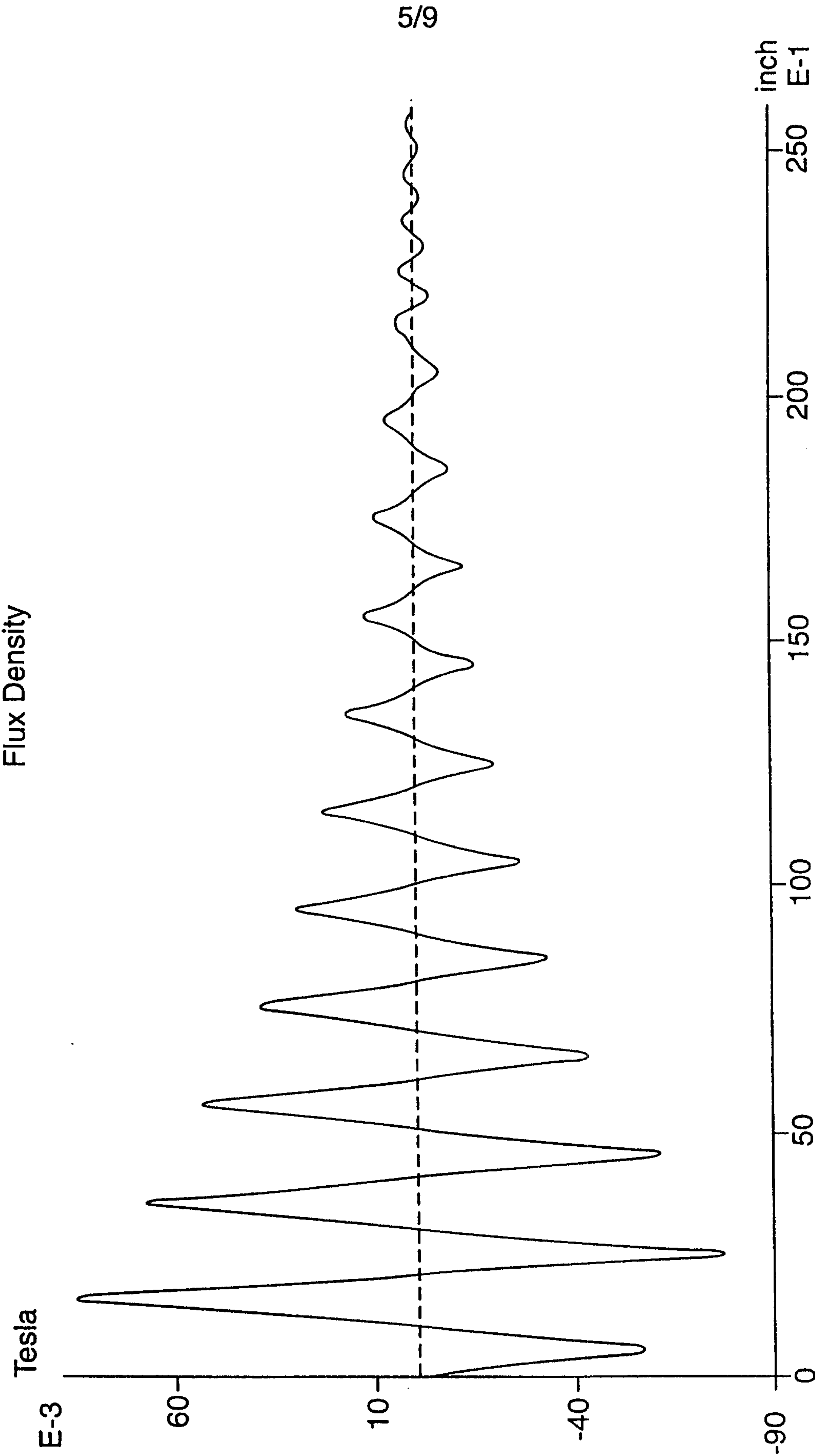
B Values At .125 Above Magnets

Fig. 4



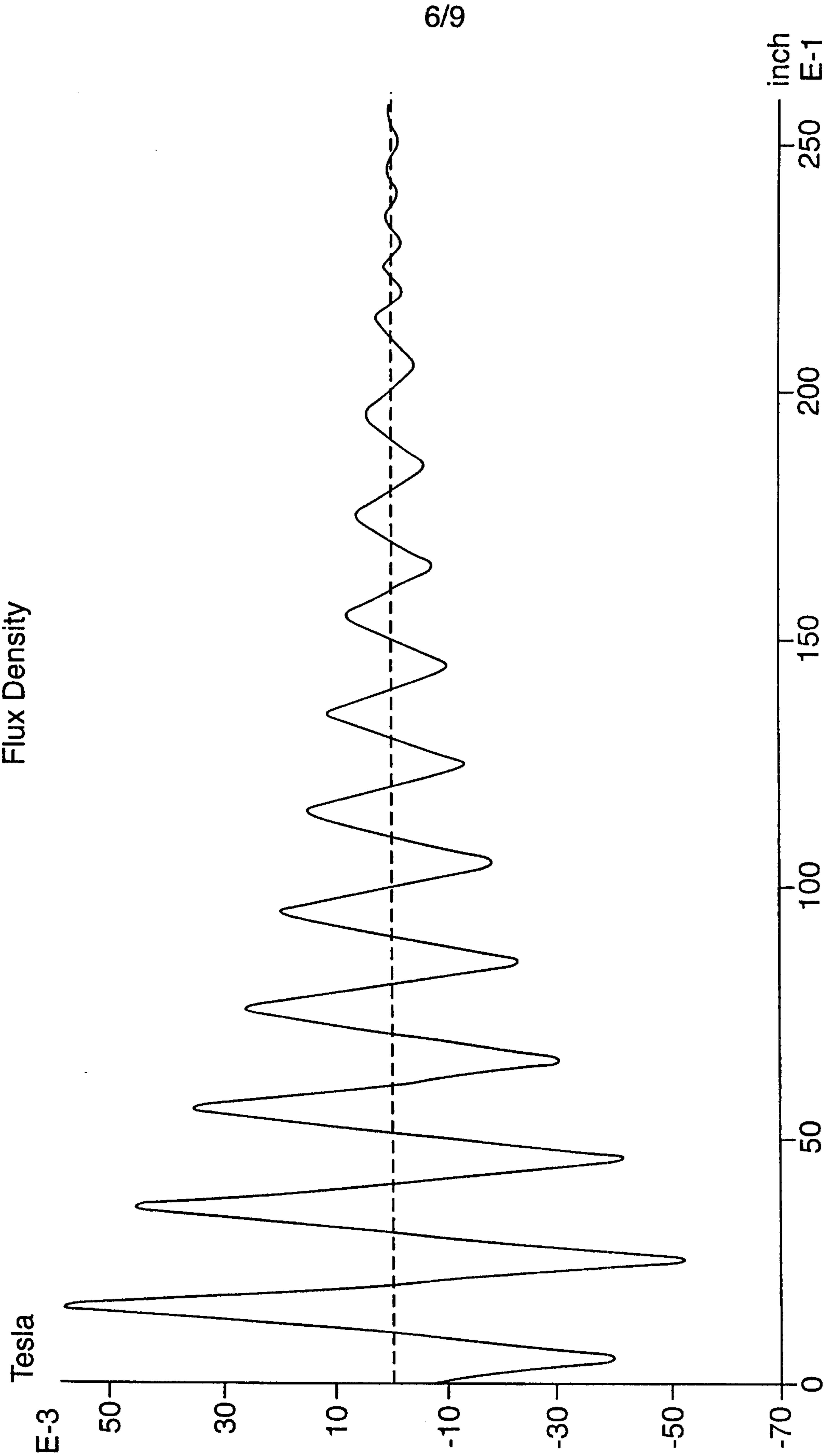
B Values At .225 Above Magnets

Fig. 5



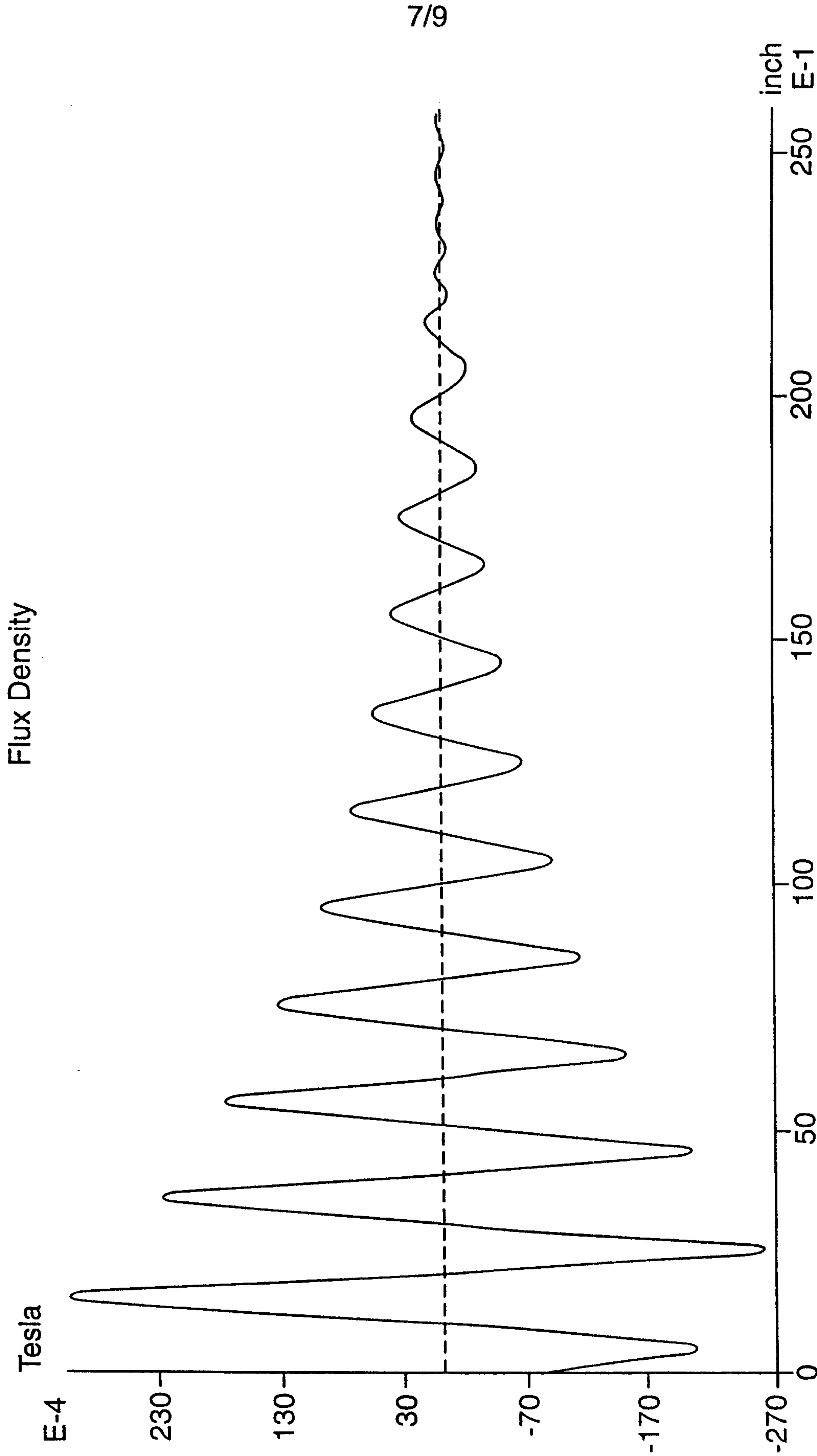
B Values At .325 Above Magnets

Fig. 6



B Values At .425 Above Magnets

Fig. 7



B Values At .625 Above Magnets

Fig. 8

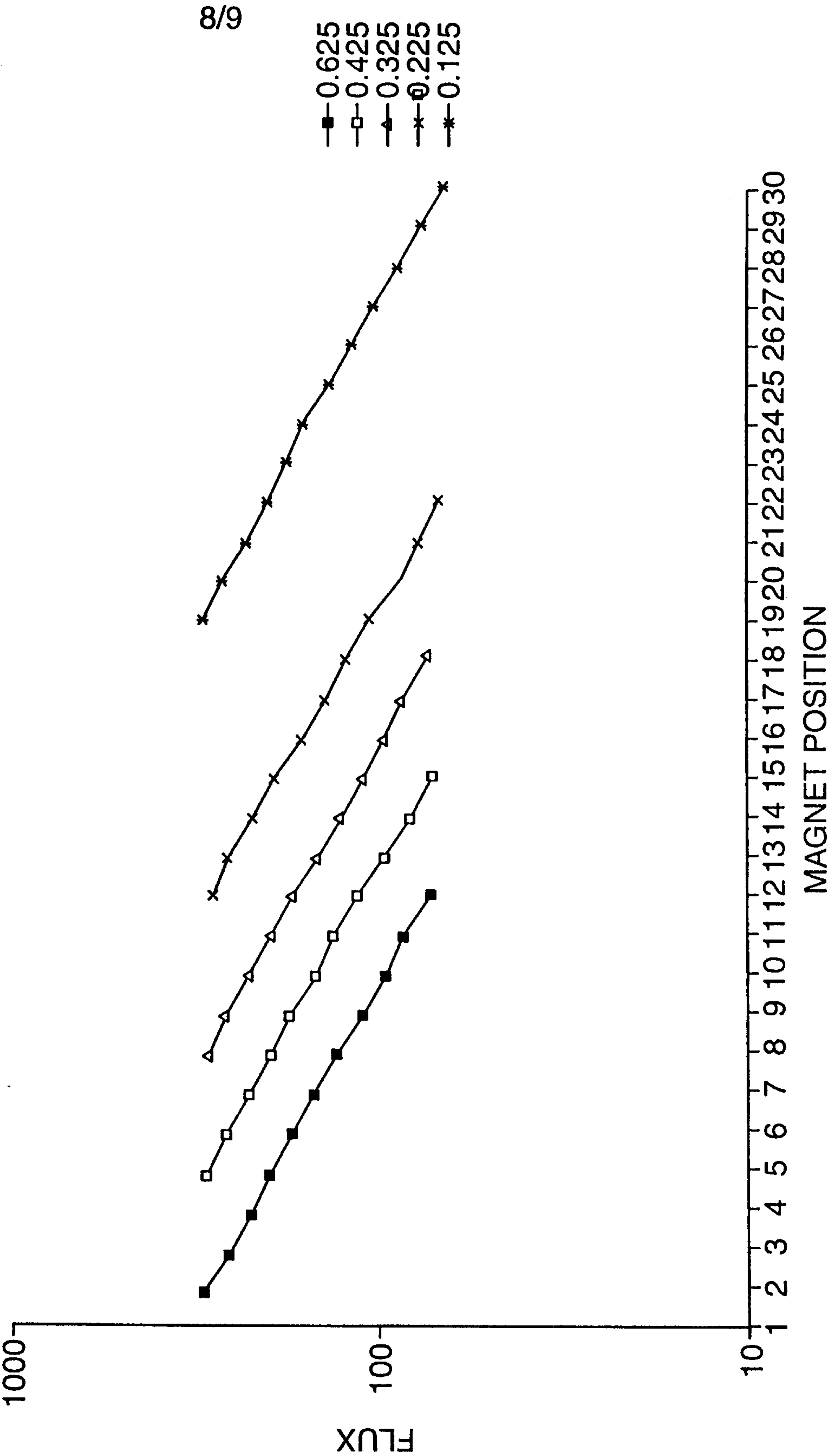
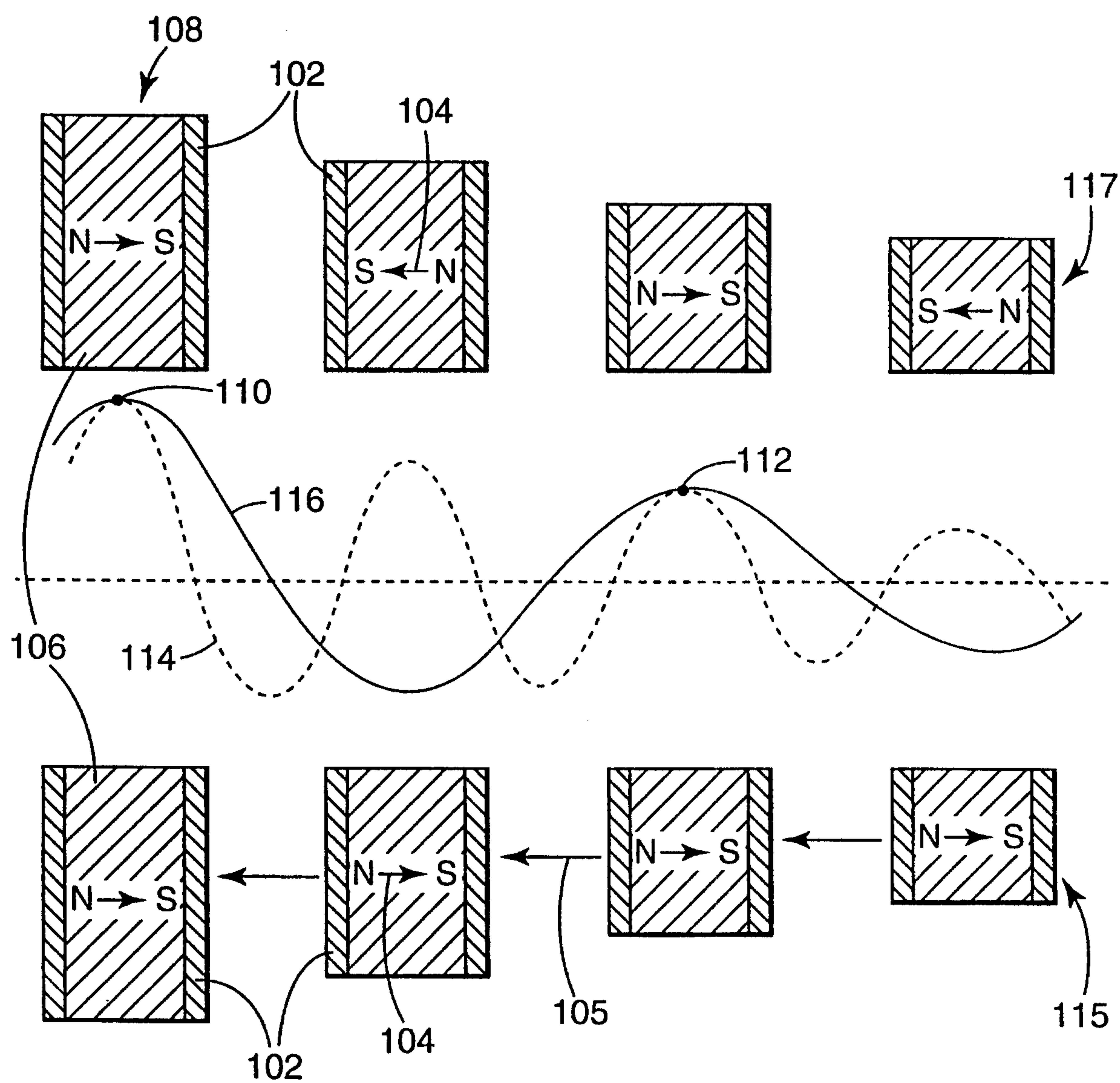


Fig. 9

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**Fig. 10**

