July 1, 1969 E. E. MASTERSON 3,453,572

CURVING FLEXURE-ARMATURE

Filed Dec. 5, 1967

Sheet 1 of 2

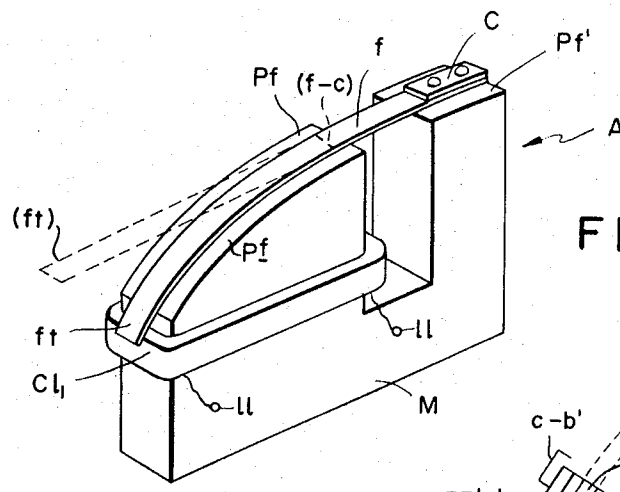


FIG. 1

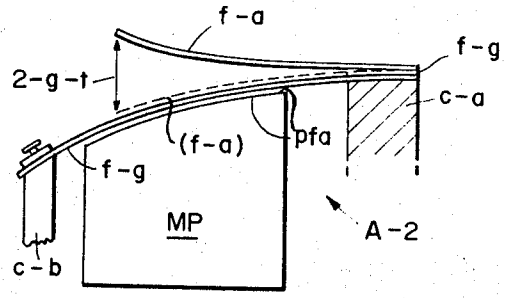


FIG. 2

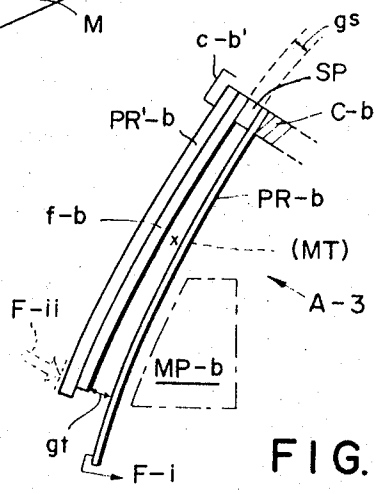


FIG. 3

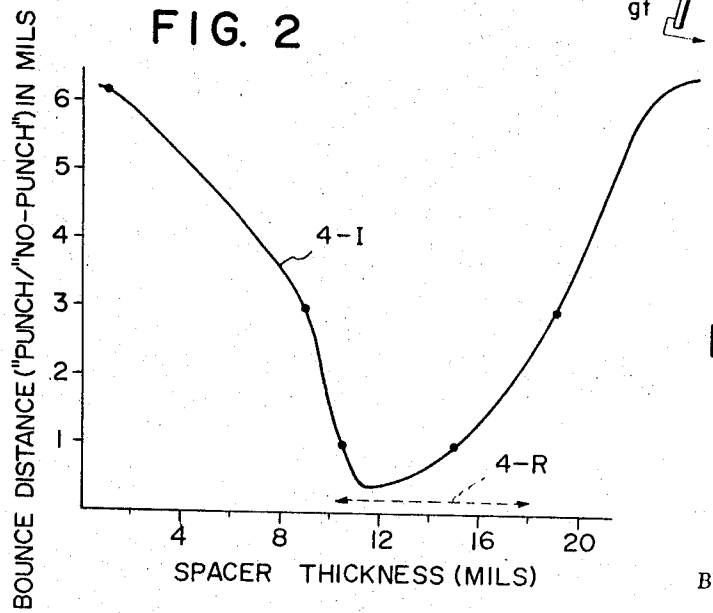


FIG. 4

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CURVING FLEXURE-ARMATURE

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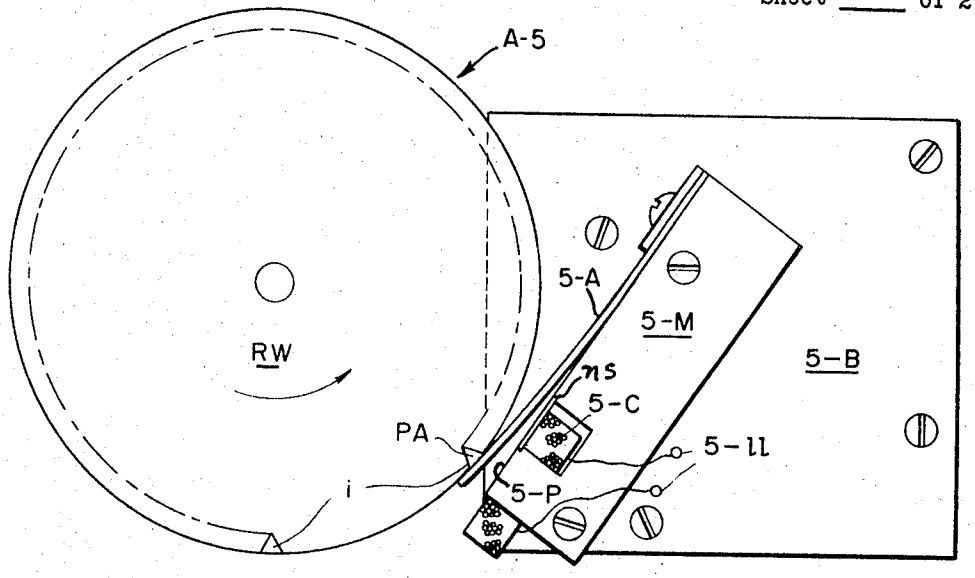


FIG. 5

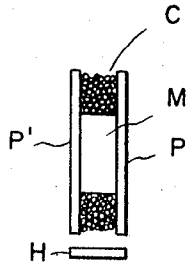


FIG. 6A

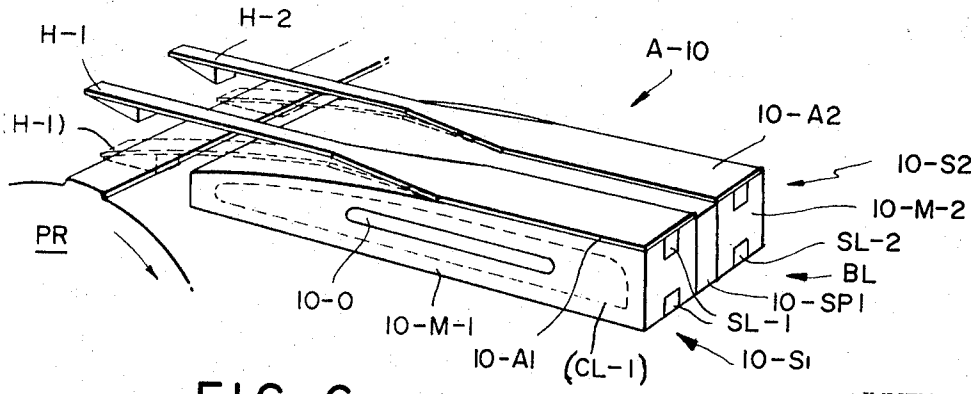


FIG. 6

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CURVING FLEXURE-ARMATURE

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Continuation-in-part of application Ser. No. 565,309, July 14, 1966. This application Dec. 5, 1967, Ser. No. 688,069

Int. Cl. H01f 7/08, 3/00

U.S. Cl. 335—276

8 Claims

ABSTRACT OF THE DISCLOSURE

A solenoid having an elongate flexure-leaf armature to be selectively attracted, pivotingly, against a pole-face surface wherein a relative curvature is introduced between flexure and pole surface so as to create a curvingly-divergent gap.

Problems, invention features

This application is a continuation-in-part of my U.S. patent application Ser. No. 565,309 filed July 14, 1966 which, in turn, was a continuation-in-part of my U.S. patent application Ser. No. 402,412 filed Oct. 8, 1964, issued in October 1966, as U.S. 3,279,690; the disclosures of both being hereby incorporated by reference in this case.

Workers in the art of providing solenoid magnetic actuators, such as those described in the aforementioned application, are well aware that a common shortcoming in the operation of such actuators is the manner of typical impact of the armature with seat or stop members. For instance, it is common knowledge that such impact can result in an "armature bounce" condition, introducing all sorts of undesirable "jitter" and other uncertainties in armature action. It is also known that such impact usually wears these impacting members to a significant degree, especially where one of the impact surfaces comprises a (typically soft) ferrous magnet-core. Thus, it is particularly desirable in this art to provide solenoid actuators minimizing undesirable armature-impact. The present invention is directed to improvement features effectuating this.

More particularly, according to the present invention, I have found that pivoting a flexible armature strip so as to establish a prescribed "divergent working gap" with respect to a magnet pole-surface and fashioning one or both of the strip and the surface to make this divergence non-linear (such as by curving the pole-surface), achieves a desirable mode of armature/pole impact. Specifically with this structure the armature is gradually "rolled down" the pole surface (or "wrapped") rather than being slapped against it, etc. as in the conventional case.

Besides the evident advantages attendant on such a "wrapping" armature-engagement, it should also be understood that in many cases, the wrapping, resilient armature provides a more efficient operation magnetically; that is, because the armature strip is flexible and because the strip and pole-surface typically curve away from one another, the "working flux" passing between them, may, in certain cases, be thought of as pulling small incremental segments of the strip somewhat independently, with the non-linear, divergent relation helping to concentrate the flux closer to the area of engagement and with the resiliency of the strip helping to lighten the "attracted load" somewhat.

Objects, features

Thus, it is a general object of the present invention to provide a device which exhibits the aforementioned features and advantages and which alleviates the aforementioned problems and objectionable characteristics. An object is to provide a device which operates to attract an elongate flexure-strip armature somewhat gradually into contact with a magnetic pole-face, to engage positively and yet without noisy or damaging impact. A related object is to increase solenoid efficiency by concentrating flux along short successive segments of a length of flexible armature strip.

Another object is to provide such a device having an armature which "wraps" gradually onto a pole-face. Still another object is to provide armature and pole-face which are fabricated to curve away from one another in a non-linear divergent gap. Still another object is to provide such a curved pole-face portion by provision of a bent flexure strip. Still a further object is to provide such a device wherein the armature strip and an associated guide strip are mounted in common with a prescribed spacer therebetween. Still a further object to provide such a device having the strips of differential length and the thickness of the spacer therebetween adjusted accordingly so as to accommodate this "wrapping" engagement mode, at least adjacent the "free-end" of the armature. Other objects will become more apparent as the following disclosure proceeds.

The foregoing and related objects, features and advantages of the invention will become more apparent from consideration of the following detailed specification including the accompanying drawings, indicating a preferred manner of making and using the invention; and wherein one type of embodiment may be described in a somewhat simplified manner as generally comprising: a flexure armature/solenoid combination wherein the engaging portion of the magnetic pole-face is curved so that the armature strip may be gradually attracted thereby to be curvilinearly engaged, or "wrapped," onto a preferred contact-plane operatively adjacent the pole-face and also, preferably, includes a flexure-guide, or pre-form, overlaid on the pole-face to define this curved contact plane.

The foregoing and other novel features, advantages and characteristics of the invention together with those related will become more apparent to those skilled in the art from the following disclosure.

The drawings, wherein like reference characters denote like parts, comprise:

FIGURE 1, an upper perspective view of one embodiment of the invention, somewhat simplified for clarity;

FIGURE 2, a schematic side section of an embodiment like that in FIGURE 1 but somewhat modified to include a flexure guide;

FIGURE 3, a simplified, fragmentary side elevation of an embodiment like that in FIGURE 2, further modified to include a pair of guides and intermediate spacer;

FIGURE 4, a plot of "bounce distance" as a function of spacer thickness in the typical operation of solenoids like that in FIGURE 3;

FIGURE 5, a very schematic side-view, in partial section, of an embodiment similar to that in FIGURE 1 but modified to function in a ratchet and pawl embodiment; and

FIGURE 6, a fragmentary, upper perspective of a set of solenoids, each after the manner of FIGURE 1, but modified somewhat to comprise a mutliple print-hammer actuator embodiment; FIGURE 6A indicating a modified version of one of the solenoids thereof.

In general, embodiment A–1 in FIGURE 1 comprises a solenoid-actuator assembly including a flexure-armature *f* and a rather "U-shaped" magnet structure, or core M, around one pole (leg) of which a prescribed coil cl_1 is wrapped. Coil cl_1 will be understood as being conventionally current-pulsed (leads **11**) so as to project an electromagnetic flux for attracting armature *f* toward pole face surface *pf*, this attraction being quite conven-

tionally effected by intersecting flux from *pf* according to phenomena well known in the art. The other leg of magnet M (or any convenient fixed base) is arranged to fixedly mount armature-flexure strip *f* (such as with the indicated clamp C on pole-face *pf'* of the other core leg) so as to be cantilevered out in flux-intercepting (attractable) relation with this attracting magnetic flux projected from pole-face *pf*. Flexure armature *f* will thus be understood as normally assuming a diverging gap relation with face *pf* so that its free tip *ft* is spaced the farthest therefrom (*f* being in rest, or unattracted, condition, in the phantom representation of FIGURE 1). Strip *f* is fabricated to comprise an elongate flat strip (flat-leaf flexure) armature of flexible, magnetizable material, such as magnetic spring steel. Workers in the art will understand that the operation of such a flexure-armature solenoid A–1 will be intended to be such that when a prescribed "attract-current" pulse "*ip*" be applied to coil cl_1 (at "actuate-time" T_A) sufficient flux will then be projected from pole-face *pf* so as to attract the intercepting portion of strip *ft* toward face *pf* (and into contact therewith in the ordinary case, as illustrated in FIGURE 1 in full-line). The flux-traversing gap *gt* between armature and pole-face is characterized as the "working gap."

Curvilinear-diverging gap

It will be apparent, however, that one feature of the construcution of A–1 is that pole-face *pf* and flexure *f* are arranged so that *pf* presents a relatively curved contact plane with respect to the "normally-flat" plane of the (unattracted) strip *f* (as more particularly described below, such as with respect to the embodiments in FIGURES 2 and 3). Thus, upon the energization of coil cl_1 and the consequent generation of flux from face *pf*, strip *f* will begin to "wrap" itself down onto face *pf*, progressively contacting it along its length. Such a gradual, incremental armature-pole-engagement may be compared with the familiar "slapping" of prior art armature structures, even those with (linearly) diverging working gaps, wherein a flat-contact plane is established, along which some or all of the armature-length may be simultaneously (rather than progressively) impacted. This curvilinear-diverging gap feature will thus effect a gradual, incremental (bending) attraction of flexure *f*, progressively pulling-in, "closer" segments thereof with increased, localized force (inverse-square variation of flux attraction with gap size) so that these segments will be rolled-down over *pf* (with the pivot-points moving down along *pf* accordingly). It will be understood that flexure strip *f* will thus be made to assume a prescribed flexing mode so as to have a prescribed known bending radius along the locus of the contact-plane and that pole-face *pf* will be accordingly fashioned to conform to it.

FIGURE 2 indicates a modified flexure-armature solenoid (actuator) embodiment A–2, to be understood as generally the same in structure and operation as A–1 in FIGURE 1 except where noted. Thus, solenoid A–2 includes a magnetizable flexure-strip armature *f–a* affixed to a fixed base member *c–a* to be cantilevered out therefrom in prescribed, magnetically-attractable relation with the pole-face *pf–a* of associated, solenoid-energized, magnet pole MP of a magnet core (only pole MP being shown). Pole-face *pf–a* is curved in the manner of *pf* (FIGURE 1) so that upon (selective) generation of magnetic flux in MP it may project flux from *pf–a* sufficient to attract armature *f–a* so as to wrap itself progressively onto *pf–a* in the aforedescribed manner. Strip *f–a* will be disposed to (in unattracted condition, the full-line showing FIGURE 2) establish a prescribed curvilinear "working-gap" separation from face *pf–a*, this gap increasing non-linearly (exponentially) along the length of *f–a* to assume a prescribed maximum-gap dimension 2–*gt* at the top thereof. However, according to a modification feature, strip *f–a* is not arranged to be "normally flat" (as in the case of strip *pf* in FIGURE 1), but is "pre-bent" as indicated (in full) away from *pf–a*, to have a prescribed radius and thereby accenutate the non-linearity of gap divergence. This construction will be convenient where it is not convenient to curve face *pf–a* very much—indeed where strip *f–a* is so pre-bent, pole-face *pf–a* may itself be flat and still effect the "wrapping" contact desired.

In some cases, it may not be convenient to fabricate face *pf–a* to a precise radius (e.g. machining expense), and, for instance, be desirable to fashion face *pf–a* to conform only roughly to the prescribed curvature. In some cases, it will also be desirable to prevent flexure *f–a* from contacting face *pf–a* however gently (e.g. risk of some abrasion etc. of typically-soft core; desirability of quick, "non-sticky" release of *f–a*, etc.). In either such case, one may provide a pole-covering guide means such as non-magnetic flexure guide *f–g* according to another feature of the invention.

For such cases, it will be preferable, as indicated here, to overlay pole-face *pf–a* with guide strip *f–g* clamped between a first base-clamp *c–a* (with *f–a*) and a second base clamp *c–b* such as to assume a prescribed (pre-bent) curved profile, and contact-plane, along which armature strip *f–a* may "wrap." The flux generated from pole MP will thus pull armature strip *f–a* gradually and wrappingly down onto guide *f–g* (the bulk of the flux passing through *f–g*). Ordinarily, one would assume that at least a portion of the gap between pole-face *pf–a* and magnetizable strip *f–a* should be "open" (i.e. left unintercepted by the body of guide *f–g*) for optimum magnetic flux-flow and inter-attraction. However, it has been found that this is not always necessary. For instance, good magnetic action has been experienced using a guide, analogous to *f–g*, comprised of non-magnetic material about 18–20 mils thick and preferably having high-flatness (e.g. about .003 TIR on the armature-engaging surface—see also aforementiond applications S.N. 402,412 and 565,309).

In embodiment A–1 above, an "exponentially diverging" (armature/pole) gap was rendered according to the curvature of the pole relative to the comparatively flat armature-strip. Of course, it will be understood that this strip need not be flat in all cases, but may, itself, be curved, such as in the case of strip *f–a* in FIGURE 2. Of course, where the armature is somewhat flatter than pole-face *pf* (that is, had a greater radius of curvature), it is more apt to "wrap" itself gradually into contact therewith. Contrary-wise, embodiment A–2 indicates how this non-linear gap-divergence may be accentuated by pre-bending the flexure (e.g. *f–a*) to curve away from the contact plane (with the magnetic pole means MP) to have an opposite radius of curvature. The resultant gap (see 2–*gt* at the armature-tip) is somewhat exaggerated here for illustration purposes. It will be understood that such a pre-bending of flexure strip *f–a* may be effected in the manufacture thereof or in the mounting thereof, such as with a clamp (not shown) adapted to cause the required bend.

A related solenoid embodiment A–3 is shown in FIGURE 3 and will be understood as constructed and operating like the foregoing embodiments except where noted. While not necessarily including the non-linear diverging gap feature, A–3 in general exhibits a "pre-bent" flexure strip armature *f–b* together with a bending flexure guide (or pre-form PR'–*b*—a feature more particularly described and explained in co-pending U.S. application Ser. No. 565,309) and, according to another feature of the invention, exhibiting a curved flexure/pole gap section. Embodiment A–3 will be recognized as comprising an attracting magnetic pole member MP–*b*, a non-magnetic curved guide (or pole-contact member, i.e. contact preform PR–*b*), cantilevered-out from a fixed base C–*b*. Clamped to the same base (e.g. by clamp C–*b'*, schematically indicated only) is magnetic flexure strip armature *f–b*, separated by a prescribed spacer Sp from guide PR–*b*. Also clamped in this manner, and superposed

bendingly against strip *f–b*, is the bending-preform PR'–*b* (clamped in common by clamp C–*b'*, cooperating as known in the art, with fixed base C–*b*). Guide PR–*b* will be understood as constrained (by schematically indicated clamp F–*i*) so as to assume a prescribed bent curvature. Similarly, bending pre-form PR'–*b* will be understood as pre-bent to assume a prescribed curvature similar to that of guide PR–*b* being understood as bent by any conventional means (e.g. stop-surface indicated functionally at arrow F–*ii* in phantom). Bending pre-form PR'–*b* is, of course, arranged to pre-bend flexure *f–b* in its static (unactuated) state. Flexure-armature *f–b* will thus be pre-bent to have a radius similar to that of inner guide PR–*b*, being somewhat shorter and cantilevered from the same clamping point C–*b*. Where the flexure armature is the same length as the contact pre-form PR–*b*, a spacer SP will not be necessary; where they differ, however (e.g. FIGURES 2, 3), I have found, according to another feature that it is highly desirable to introduce a spacer SP of prescribed separating-thickness to improve their mode of engagement.

Where spacer SP is used, I have found that its thickness is relatively critical and depends upon the length differential. For instance, in an arrangement like A–3, if spacer-thickness *gs* is too small (or SP is omitted entirely), problems will arise in operation of flexure *f–b*; for instance, its contact with PR–*b* will be too intimate over too great a surface area for "quick-release" and can also present an undesirably large bending moment (depending on the stiffness of *f–b*), e.g. such that either too much magnetic flux is required to attract it or else such that *f–b* will not wrap completely along PR–6 and, typically, never engage at its tip, *ft*.

Conversely, if spacer SP is overly thick, and/or if strip *f–b* is not stiff enough relative the applied magnetic force, the strip may tend to contact PR–*b* unevenly and not gradually, tending to "slap" its tip *ft* against PR–*b* prematurely (rather than gradually wrapping along its length). It will be apparent that in such a case, damaging contact-abrasion, noise "bounce" (cf. below) and the like will be encouraged and that too little surface area of strip *f–b* will engage with the guide, tending to allow disengagement prematurely (e.g. "bounce"; poor "hold" forces, etc.). Thus, a spacer SP having a prescribed thickness range (e.g. as suggested below) is found preferable according to the invention; for instance, such a thickness as will cause the cantilevered length of strip *f–b* to contact guide PR–*b* gradually and continuously, along most of this length (i.e. substantially to its outer free end).

Moreover, in cases of a length-differential (different lengths of armature strip *f–b* and pre-form PR–*b* as aforementioned) I have found, according to this feature, a particular need for spacer SP to effect better engagement of these members. That is, where pre-form PR–*b* is significantly longer than strip *f–b* (assuming that bending guide PR'–*b* keeps them relatively parallel), the strip will tend to "buckle" along PR–*b*, leaving an intermediate portion of its length "standing off" from PR–*b*, "hump-like," when its tip *ft* has engaged PR–*b* (this engagement is also more apt to be a "slapping," nongradual, one, inducing "bounce"—as seen below). The greater this differential is, the thicker SP must be. On the other hand, where guide preform PR–*b* is significantly shorter than strip *f–b*, it will tend to "slap" its tip *ft* prematurely against PR–*b* (in the aforementioned manner, with the described effects) and not "wrap" gradually therealong.

The foregoing limitations on spacer thickness may be illustrated by reference to particular dimensional embodiments for arrangement A–3. For instance, spacer thickness may be adjusted, according to a particular feature of the invention, to minimize "armature bounce." This may be understood with reference to the curve in FIGURE 4, where I have found the following: Using U-shaped clamp C–*b'* etc. and an armature strip *f–b* like that in the aforementiond applications (about 1¾ in. eff. length and about ¼–⅛ in. wide and 12 mils thick, with guide PR–*b* about ¼ in. longer) together with a spacer SP about 20 mils thick, a serious "bounce condition" was discovered whereby strip *f–b* would be attracted by solenoid pole MP–*b*, when the latter was energized, so that its tip slapped against guide PR–*b* such as to rebound one or more times (note the danger of accidentally rebounding back towards PR'–*b*, i.e. into the "on" condition, and thereby inducing accidental, erroneous actuations, etc.). The amplitude of such bounces were severe enough to comprise about 10 mils or more where the nominal minimum armature/guide gap *gt* was arranged to be only about 18 to 25 mils—introducing the risk of accidental actuation. This condition is reflected in curve 4–I where the 20 mil spacer could produce a bounce distance in the neighborhood of about 7 mils. It was also found that reducing the spacer thickness too much also produced an undesirable amount of bounce (cf. curve 4–I) and that there was an intermediate thickness range 4–R from about 10 to 18 mils (prefer 10–15) that was optimum for minimizing bounce in this embodiment. This corroborates the aforementioned "thickness" critically, although the underlying phenomena are not wholly understood as yet.

Of course, bounce may also be reduced more conventionally, such as by increasing the attracting magnetic force, decreasing the effective gap between armautre *f–b* and magnet MP–*b* etc. It was also found that reducing the thickness of strip *f–b* from about 12 mils to about 10 mils reduced the amount of bounce (presumably because this makes the air gap about 2 mils less and the magnet pole MP–*b* more effective in moving strip *f–b* which is thus rendered less stiff). Of course, as aforementioned, one must be careful not to force too great an area of strip *f–b* into intimate engagement with preform PR–*b* since the release time and associated energy will then be too great, and "release" too slow). One way of avoiding this is to increase spacer thickness, aside from other considerations (such as length differential).

Another embodiment of the invention is indicated in FIGURE 5 where a modified solenoid actuator A–5 is shown, being intended to function in the manner of a pawl actuator for a conventional (schematized) ratchet wheel RW. Here actuator A–5 takes the form of a flexure armature solenoid with the tip of the armature flexure strip 5–A being fitted with a detent PA arranged to be indexed registeringly into notches *i* cut in a periphery of ratchet wheel RW. The general operation of this arrangement will be well known in the art whereby energization of actuator A–5 will drive dentent PA (pawl-like) into and out of notches *i* to control the rotation of wheel RW (arrow). Actuator A–5 is like the aforedescribed solenoid actuators except as noted and generally comprises a solenoid magnet 5–M mounted on a fixed plate 5–B (in any convenient manner, so as to assume a fixed position for control of RW), magnet 5–M inculding a prescribed pole-leg adapted to present a (very slightly indicated) curved pole surface 5–P in operation relation with a portion of strip 5–A and to be selectively energized by associated solenoid coil 5–C as known in the art. Flexure strip armature 5–A is magnetic and resilient, being clamped onto magnet 5–M to be cantilevered out in confronting relation with curved surface 5–P and also, preferably, pre-bent so as to create a non-linear diverging gap therebetween in the aforedescribed manner and to be wrapped gradually and continously thereonto when attracted by emanating magnetic flux. This gap is established acocrding to the relative curvature of pole-face 5–P (here indicated as being relatively flat, though it could have been curved) and by the clearance of PA with RW in rest condition. It will be seen as very useful to arrange strip 5–A so as to present a "stiff-arm" resistance to the rotation of wheel RW when detent PA is locked in an associated notch *i* (i.e. not buckle). It will be assumed that in its normal, static, condition, strip 5–A will present

detent PA so that it wall fall into a registering notch *i* and oppose the rotation of wheel RW. Thus, upon the energization of coil **5**–C, strip **5**–A will be attracted to be wrapped, somewhat gradually and continuously, along curved pole-face **5**–P and thereby remove detent PA from stopping engagement with wheel RW (e.g. RW may be continuously urged for this, such as by a spring-drive). The current through **5**–C would be applied until wheel RW is to be stopped whereupon its cessation would release armature **5**–A to spring back toward wheel RW, and allow detent PA to seat in a following associated notch *i*. Armature **5**–A should, preferably, be of flexible, durable metal, such as of hardened steel, and will thus have less than perfect magnetic properties, however, still being operable. It may be helpful to taper the cross section of **5**–A to make it flex in a "truer" arc (e.g. per FIGURE 6) and thus produced constant stress along its length as it conforms to the desired arcuate locus. As known in the art, an "anti-stick" shim surface may be provided on at least a portion of armature **5**–A (or any like armature) for quick-releasing engagement with pole **5**–P. Also, a nonmagnetic spacer *ns* may be provided over the cavity receiving coil **5**–C, offering a guide surface for strip **5**–A to wrap upon so that it doesn't buckle there.

Another modified embodiment of the invention is indicated in FIGURE 6 where a plurality of solenoid actuators, somewhat like those aforedescribed, are shown as formed into an integral actuator set A–**10** functioning in the manner of a set of print-hammer solenoid actuators for use in a relatively conventional high-speed printer arrangement. This arrangement will be understood as including a conventional drum PR (schematically indicated) with each actuator **10**A in the set A–**10** taking the form of a flexure-armature solenoid with the tip of the armature-flexure strip **10**–S being adapted to present a print-hammer H at the free tip thereof. In general, print drum PR may be understood as conventionally presenting successive rows of raised-type font for the selective impacting thereof by an associated hammer H at a prescribed "select time." As understood in the art, when particular printing media (e.g. paper and ribbon) is presented between the set of hammers H and drum PR (such media not shown, but well understood in the art), proper timed energization of coils *cl* associated with prescribed actuators **10**–A will effect printing on this media at an associated print-column position thereon (by the impacting of hammer H onto the paper and against the type-font, then positioned behind it, etc.). Except where specified, each actuator **10**–A will be understood as functioning in the manner of those aforedescribed, and including a magnet portion **10**–M, a coil *cl* and a magnetizable flexure-strip armature **10**–A pivotingly mounted on the working pole-face of the magnet so that with a non-linear diverging gap established between this strip and the pole-face as indicated in the drawing by the curvature of the pole-face, a gradual continual wrapping engagement of this strip onto the pole-face will be effected to, in turn, impact the hammer portion H for printing. Strips **10**–A (e.g. **10**–A1 with magnet **10**–M1 and hammer H–**1**) may be mounted to so project above the associated pole-face in any convenient manner such as by clamping attachment to one end of the pole-face as indicated and will be arranged to project beyond the pole-face portion to effect this impact with the print-roll PR described. The integral set of actuators **10**–A may be mounted in alignment such as by provision of an alignment bore **10**–O through which a common mounting means may be registeringly inserted or the like.

For optimal magnetic isolation between actuators, nonmagnetic spacer blocks **10**–SP (e.g. **10**–SP–**1** between solenoids **10**–S1 and **10**–S2), may be provided therebetween as indicated. This, of course, means that each actuator magnet block **10**–M will be quite narrow having a width on the order of the width of a typical print-column (somewhat less where blocks **10**–SP are to be accommodated). It will be recognized that the simple uncluttered configuration shown will lend itself to the provision of such miniaturized actuators in compact environments like the printer indicated. It will be recognized that among other advantages the provision of the described "non-linear, diverging working gap" will desirably provide a gradual controlled impacting of the hammer head, together with a controlled self-biased return thereof.

Where advantageous, each individual actuator **10**–S may be fabricated as indicated in FIGURE 6–A according to a modified simplified structure to comprise a central, permanent-magnet core *m* (such as a ceramic magnet poled to attract the associated flexure strip H in a prescribed direction, toward, or away from, the assembly) and a pair of magnetizable, low reluctance pole plates P, P′, attached on either side of magnet M to effectively form coil-receiving, flux-directing members, between which solenoid coil *c* may be wrapped for magnetic energization of the assembly.

Having now described the invention, what is claimed as new and intended to be secured by Letters Patent is:

1. An electromagnetic actuator assembly for use in connection with a working surface, said assembly comprising:
- a magnetic core having an outwardly curved pole face;
- flux means for selectively generating magnetic flux within said core;
- means forming a working element in selected disposition relative to said working surface;
- a flexible elongate magnetic armature having a first end mounted in fixed relationship to said core and a second end fixed to said working element, said armature being suspended over said pole face to define a non-linearly diverging working gap therebetween;
- whereby generation of a predetermined magnetic flux level within said core attracts said armature into gradual, progressive contact along the curved pole face to move said working element into low rebound impact with said working surface.

2. An electromagnetic actuator assembly as described in claim **1** wherein:
- the curvature of said pole face and the shape of said armature define an exponentially diverging working gap.

3. An electromagnetic actuator assembly as described in claim **1** wherein:
- said flexible armature comprises a narrow strip, curved between said first end and said second end.

4. An electromagnetic actuator assembly as described in claim **1** wherein:
- said core is supported within an outer frame upon which the first end of said armature is mounted; and
- said curved pole face is masked by a thin correspondingly curved strip fixed to said frame.

5. An electromagnetic actuator assembly as described in claim **4** wherein said strip is formed of non-magnetic material.

6. An electromagnetic actuator assembly as described in claim **4** wherein:
- a spacer is fixed between the first end of said armature and said frame to provide a working gap of predetermined minimum dimension; and
- a preformed elongate guide is fixed to said frame, overlying the armature, whereby said armature will conform to the shape of said guide when the flux means are unenergized.

7. An electromagnetic actuator assembly as described in claim **1** wherein:
- said working element comprises a print hammer adapted to move into low rebound contact with a print drum when said actuator is energized.

8. An electromagnetic actuator assembly as described in claim **1** wherein:

said working element comprises a detent adapted to be withdrawn from one of a plurality of notches in the periphery of a rotatable member when said actuator is energized.

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