United States Patent

[11] **3,618,124**

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[73] Assignee **The Magnavox Company**
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[54] **FACSIMILE TRANSDUCER**
12 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **346/141,** 179/100.41, 335/222
[51] **Int. Cl.** **G01d 15/20,** H04n 1/24
[50] **Field of Search** ..... 346/139, 141; 335/271, 277, 257, 247, 222; 324/125; 310/51, 17, 15; 179/180, 100.41 ED, 100.41 ST; 248/15; 73/430

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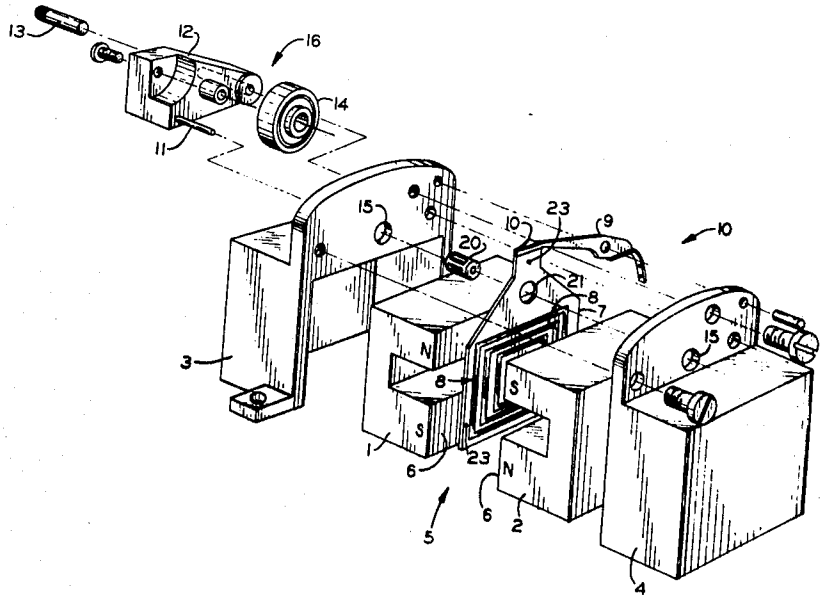
ABSTRACT: The disclosure describes an improved facsimile writing head of the moving coil type and particularly relates to an arrangement for providing a moving coil structure having low friction positioning and bearing surfaces and for providing mechanical damping of undesired oscillations and vibrations of the structure.



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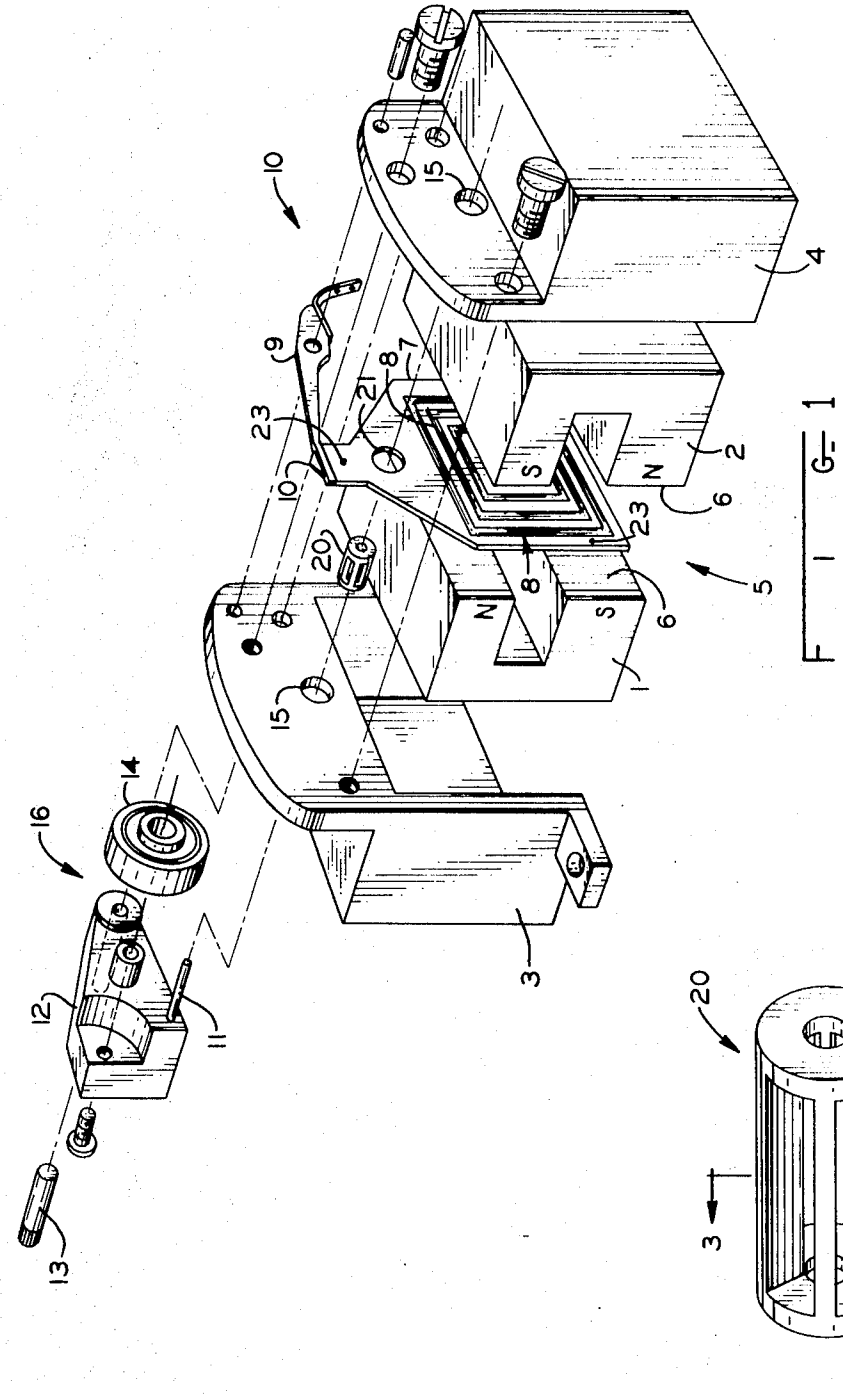

FIG. 1

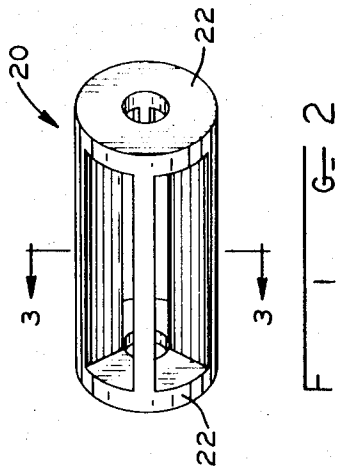

FIG. 2

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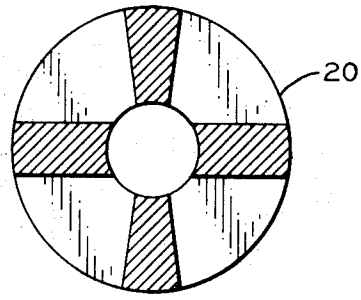

FIG 3

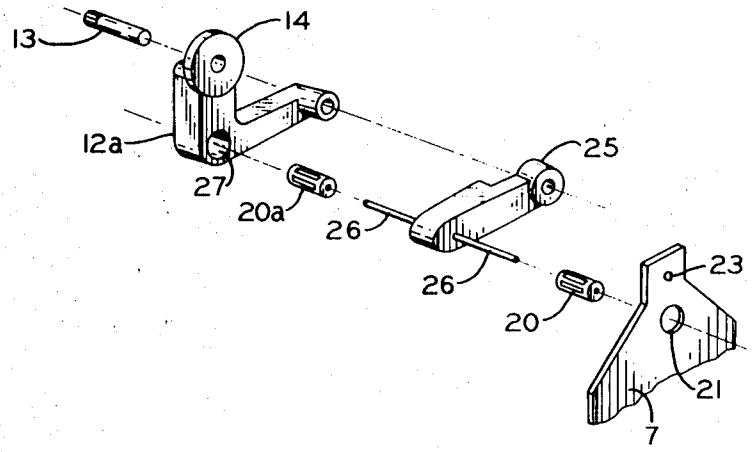

FIG 4

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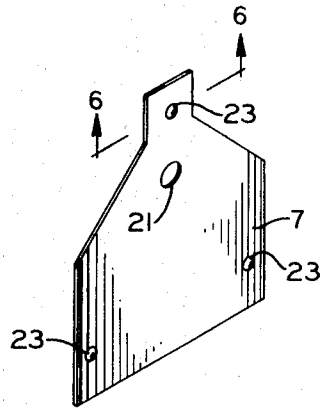

FIG 5

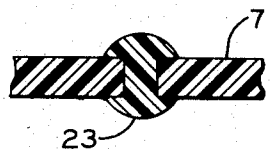

FIG 6

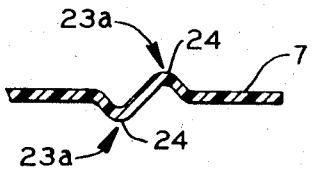

FIG 7

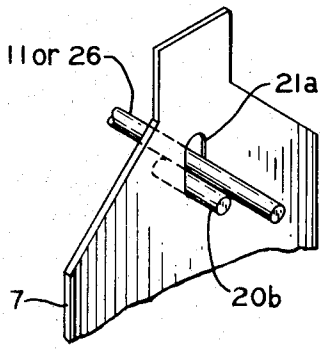

FIG 8

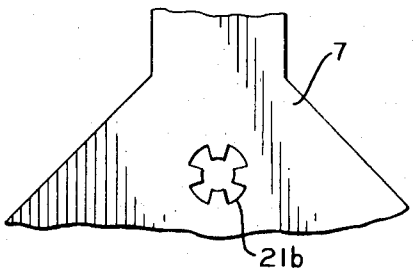

FIG 9

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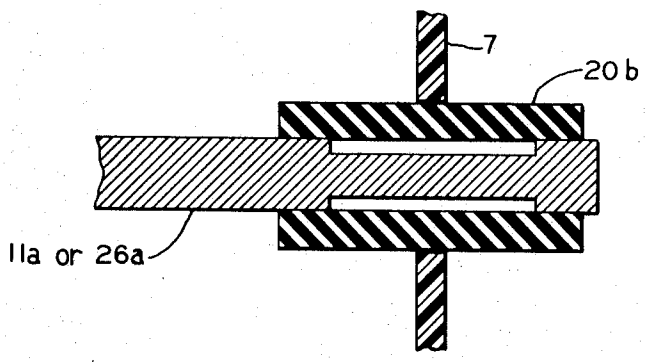

FIG. 10

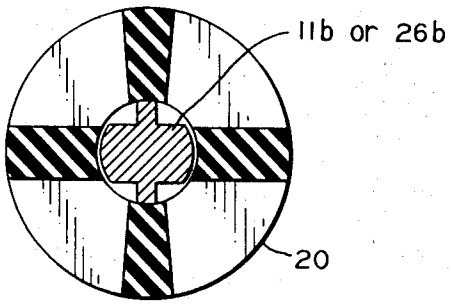

FIG. 11

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FACSIMILE TRANSDUCER

CROSS-REFERENCE TO RELATED PATENTS

The present invention may be utilized in a facsimile transducer printing means similar to that disclosed and claimed in U.S. Pat. No. 3,325,821 entitled "Multispot Transducer" issued June 13, 1967 in the names of Glenn A. Reese and Donald H. Westermeir and assigned to The Magnavox Company.

FIELD OF INVENTION

The present invention relates to an improved writing head or transducer for use in facsimile reproduction apparatus or the like.

BACKGROUND OF INVENTION AND PRIOR ART

In a facsimile machine there are a number of ways of converting or transducing an incoming facsimile signal to a reproduction of the original document. In the facsimile system described in the aforementioned patent, the electrical signal is converted into a mechanical force which, by means of a suitable writing stylus, acts upon a pressure sensitive material such as carbon paper, causing a facsimile reproduction to be created upon an underlying copy paper. The writing heads or transducers are rotated rapidly in a single plane across the surface of the paper and the paper is simultaneously fed past the rotating head in a direction perpendicular to the rotational plane of the heads so as to reproduce the entire facsimile copy.

In order that the reproduced copy be a faithful reproduction of the original, it is desired that the transducer's mechanical writing force have a constant ratio or linear relationship to the amplitude of the electrical input signal representing the original document. It is desired that this linear relationship exist throughout the entire facsimile baseband frequency range. A nonlinear relationship, for example, may result when any or a combination of the transducer's mechanical parts are resonant at frequencies within or below the desired band of operating frequencies. The various mechanical parts of the transducer which develop or transmit the mechanical writing force can distort and hence store undesired energy thereby resulting in undesired oscillation and resonant effects. Such conditions cause a mechanical writing force which is not linear with respect to the input signal.

Damping of these undersired oscillations and vibrations will tend to minimize and control the undesired effects resulting therefrom and a properly damped transducer will have a mechanical output force which faithfully represents the electrical input signal. Excessive damping, however, is undesirable as this results in a loss of transducer sensitivity.

Mechanical oscillation or motion may be damped by numerous methods, both electrical and mechanical. As an example, the winding of the moving coil of the transducer described herein might itself be used as an electrical damping means. By utilizing a very low impedance electrical driving circuit for the transducer, the moving coil or armature winding in the normal magnetic field would act as a short-circuited winding thereby tending to oppose any undesired change in motion of the armature or coil card not corresponding to the electrical input drive signal to the transducer. The degree of damping which can be realized in this manner is, however, limited by the electromechanical efficiency of the transducer which in such devices is usually too low to permit attainment of the desired degree of damping. A mechanical friction type of damping might also be used in the transducer described; however, with this type it is very difficult to control the damping to a constant desired degree. Former constructions have also utilized damping members in the form of suspension devices for the armature or coil card of the transducer. Such damping means is not highly efficient and the damping material itself is usually not stressed to any great degree by the motion of the transducer's moving coil structure. Viscous fluid damping might also be used, but proper sealing of the fluid creates mechanical problems and their solution generally results in an increase in the complexity of the construction of the the transducer.

SUMMARY OF THE INVENTION

It is the principal object of the invention to provide an improved facsimile transducer structure which exhibits a substantially linear relationship between the electrical input signal and the mechanical output writing force.

A further object is to provide a facsimile transducer of the moving coil type which has a highly efficient means to damp undesired oscillations and vibrations and which damping means is simple, reliable, rugged and not easily injured.

Another object is to provide a facsimile transducer damping structure where the mechanical vibration stresses within the damping material is maintained at a maximum.

Another object is to provide a facsimile transducer means which exhibits a minimal affect upon the sensitivity of the transducer.

Still another object is to provide an improved facsimile transducer wherein damping is accomplished with a minimum addition of stiffness and mass to the moving structure.

Still another object is to provide a facsimile transducer of the moving coil type wherein the moving armature or coil card is provided with low friction positioning and bearing surfaces.

A further object is to provide an improved facsimile transducer of the moving coil type having a mechanism for establishing a relative position between the writing stylus and the copy material wherein there is provided a vibration decoupling means between the stylus positioning mechanism and the armature or moving coil card.

In a facsimile reproduction system which utilizes more than one printing transducer such as described in the previously referenced related patent, it is important that each transducer have uniform and substantially identical printing or writing characteristics since in such a system, the reproduced copy is a result of the combination of the printing ability of each individual transducer. It is therefore a further object of this invention to provide an improved facsimile transducer structure which exhibits more uniform and matched printing characteristics between all such transducers manufactured.

Briefly these and other objects which will be later apparent to those skilled in the art are attained in a facsimile transducer of the moving coil or armature type having a lightweight armature or coil card maintained in a predetermined crosswise position in a magnetic airgap by positioning surfaces with the positioning surfaces allowing the armature or coil card to move with a minimum of resistance or friction in a direction necessary for writing and at right angles to the airgap flux path. Damping of the structure is accomplished by means of a resilient damping member disposed within an aperture in the coil card and arranged so as to be stressed as a result of movement of the coil card.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of the improved facsimile transducer showing one form of damping and coil card bearings described herein.

FIG. 2 is a view of the damper utilized in FIG. 1 and illustrates end discs.

FIG. 3 is a cross-sectional view of the damper of FIG. 2.

FIG. 4 is a perspective view of another damping embodiment in accordance with the invention.

FIG. 5 is a perspective view of the coil card showing the bearing surfaces of the invention.

FIG. 6 is a cross-sectional view of one of the bearing surfaces of FIG. 5.

FIG. 7 shows another type of bearing surface for the coil card.

FIG. 8 shows a coil card using only one piece of damping material.

FIG. 9 shows a coil card with a spline shaped hole for mating with a damping member.

FIG. 10 is a sectional view of another damping embodiment in accordance with the invention.

FIG. 11 is a sectional view of the damper of FIG. 2 with a modified pin.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 there is shown an embodiment of the invention incorporated in a moving coil facsimile transducer such as disclosed in the aforementioned patent to Reese et al. The transducer consists of a pair of permanent magnets 1, 2 which, when mounted in their respective housings 3, 4, provide a relatively narrow and uniform air gap 5 between the magnet pole faces 6. The armature or coil card 7 is disposed in the airgap and in the magnetic flux field resulting from the permanent magnets 1, 2. The armature or coil card 7 is arranged so as to be free to move in a substantially vertical direction as viewed in FIG. 1. The armature or coil card 7 is preferably of a very thin and lightweight material and may be of printed circuit type construction consisting of an etched conductive coil winding 8 on a thin and nonmagnetic insulating board or substrate. When transducer input current is caused to flow through the coil winding 8, a dynamic flux field will be established around the winding of the coil card which will react with the flux in the airgap causing a force to be produced on the coil card resulting in movement of the card in a vertical direction as viewed in FIG. 1. This force caused by the reacting magnetic fields will be proportional to the amplitude of current flowing within the winding 8 of the coil card 7. Movement of the coil card 7 is transmitted to the writing stylus 9 which bears against the pressure sensitive copy material as previously described.

The follower mechanism 16 is operatively interconnected with the stylus 9 by means of the coil card 7, damper 20 and pin 11, and provides a means to position and stylus writing point or apex 10 relative to the surface of the pressure-sensitive paper to provide a uniform printing characteristic. The arm 12 pivots on pin 13 which is secured to the housings in any desired fashion. The follower roller 14, such as a ball-type bearing, rides against a thin sheet of pliable material, such as plastic. Thin pliable sheet overlays the pressure sensitive carbon paper and its backing blank copy paper including the carrier platen which are not shown in the drawings. This thin pliable sheet compresses the pressure sensitive paper and the copy paper tightly together against the platen to reduce the clearance between the papers to a minimum and uniform degree. The pliable sheet terminates adjacent to the transducer printing area thus allowing the follower 14 to ride on the surface of the pliable sheet while allowing the stylus 9 to exert the necessary mechanical writing force against the pressure sensitive paper.

The damping embodiment shown in FIG. 1 consists of a damper member 20 positioned within the aperture 21 of the coil card 7 and around the follower assembly pin 11. The damping member shown consists of four strips of suitable damping material, symmetrically positioned about the periphery of pin 11. Although four strips or pieces of damping material are shown, other quantities may be used. The damper member of FIG. 1 may use discs on each end of the strips to maintain relative alignment of the strips. A damping member with such discs 22 is shown in FIG. 2. FIG. 3 shows a cross section of the damper of FIG. 2 taken at section 3—3. The damper may be molded or fabricated as desired. It is preferable that the damping strips be in contact with the edges of the coil card aperture or hole 21 and the outside diameter of the pin 11. The damping member of FIG. 2, for example, is therefore dimensioned so that there will be a slight interference fit of the damping member with the mating coil card hole 21 and pin 11. The holes 15 in the housing should be large enough in diameter to allow sufficient clearance for movement of the damping member in order not to restrict normal movement of the coil card.

The damping member 20 responds to movement of the armature or coil card 7 and such movement causes a change in compression and/or tension of the damping material. The material of the damper distorts much like a viscous fluid and some of the energy causing movement is converted into heat and is dissipated. This energy is therefore effectively lost, as desired, rather than being stored. The dissipated energy thus damps and effectively controls undesired oscillations such as those resulting from mechanical resonances and/or other undesired vibrations of the moving structure.

In some instances warpage or bending of the coil card 7 will create additional and undesired friction affecting the free and normal movement of the coil card. As an example, a slightly warped coil card could, during movement, rub against the magnet pole faces or housings thereby resulting in an interference condition which would tend to restrict desired movement of the coil card. Such interference could cause improper transducer write out and affects the damping efficiency. To achieve more uniform transducer operation and performance, it is therefore preferable that the friction of the moving coil card be at a minimum and be controlled. This is accomplished by the use of bearings 23, of low-friction material such as Teflon or the like which are affixed to the coil card 7 preferably in three locations on the coil card as shown in FIG. 5. The two lower bearings ride against the lower pole faces 6 of the permanent magnets 1, 2 and the upper bearing against the inside surfaces of the housing 3,4. FIG. 6 is a cross section of the upper bearing 23 of FIG. 5 through the section 6—6. The bearing 23 may be formed by heading over a rivet of suitable material in the coil card as illustrated by FIG. 6. In FIG. 7, the bearing 23 is fabricated by forming small dimples 23*a* on opposite sides of the coil card at the desired bearing location so as to provide small bearing surfaces 24. The bearings 23 not only provide low-friction sliding surfaces for the coil card, which greatly improves the uniformity, accuracy, and response time of the transducer, but also provides for the centering or positioning of the coil card in the airgap and allows some coil card warpage or bending to occur without creating excessive friction. It is preferable that three bearings 23 be used on the coil card positioned in a triangular relationship; however, other quantities and mounting positions or locations may be used. It is also possible to have low-friction bearing surfaces affixed to the transducer structure in lieu of the coil card; the coil card would then ride against and between the low-friction bearings.

The embodiment of the invention described above and shown in the referenced drawings provides an efficient damping means with minimal affect upon the transducer sensitivity. Actual embodiments have exhibited a substantially linear input-output relationship.

The damping embodiment illustrated by FIG. 1 may be regarded as utilizing only one compliance or damping member and one effective mass and, even though its performance is highly satisfactory, it may be further improved by using more than one mass and one damping member. In the exploded view of FIG. 4 there is shown a modification of FIG. 1 where two damping members and two effective masses are employed. In this embodiment, an additional mass or arm 25 having inertial properties has been added between the coil card 7 and the original mass or roller arm 12*a*. The mass arm 25 is pivoted as is the roller arm 12*a* on pin 13 which is attached to the housing of the transducer. The two arms 12*a* and 25 are free to pivot separately from one another. The arm 25 contains a pin 26 which protrudes from each side of the arm and mates with each respective damping member 20 and 20*a* with the same type of interference fit previously described for damping member 20 and pin 11 of FIG. 1. The damping members 20 and 20*a* are identical but need not be. The roller arm 12*a* as shown in FIG. 4 has a different configuration or shape than that of arm 12 shown in FIG. 1 but may be the same if desired. Arm 12*a* contains an aperture 27 which mates with the damping member 20*a*. The fit between the damping member 20*a* and the arm aperture 27 as well as that between

damping member **20** and coil card aperture **21** of FIG. **4** is preferably the same type interference fit as previously described for the damping member **20** and coil card aperture **21** of FIG. **1**. The aperture **27** may be counterbored so as to leave an internal portion having approximately the same contact surface area against the damper **20***a* as is provided between the coil card **7** and damper **20**. For the same total degree of damping as may be obtained with the embodiment of FIG. **1**, the FIG. **4** embodiment will result in an increase in transducer sensitivity. The FIG. **4** embodiment can also provide a greater degree of isolation between the follower **14** and the coil card **7** thus reducing the transmission of any undesired vibration occurring at the follower **14** to the coil card **7** and stylus **9** which could result in a degraded reproduced copy.

The damping material as used in the embodiments of this invention may be a rubber having a high hysteresis characteristic; however, other types of materials may be used. It is, of course, preferred that any material used have good strength and be resistant to tearing and have long useful life. It should retain its desirable characteristics regardless of environmental operating or storage conditions such as, for example, temperature.

Several other embodiments and variations of this invention might be made without departing from the scope thereof; for example: it may be desirable to use only one strip of damping material such as shown in FIG. **8**. The hole **21***a* may be elongated and a single piece of damping material **20***b* used. The damping material **20***b* in FIG. **8** may be placed on the stylus side of the pin **11** in lieu of the position shown. In some instances the card **7** may tend to bow or bend upon being driven into the pressure sensitive paper and its backing material and will, in this position, tend to store energy which can be absorbed by the damping material when positioned on the stylus side of the pin. The hole **21***a* might also be elongated further and two pieces of damping material used on both the top and bottom side of the pin **11** or **26** of FIG. **8**. Further, it is not necessary that the aperture in, for example, the coil card be circular or oblong. It may take other forms such as square or spline-shaped hole. FIG. **9** shows a spline-shaped hole which may be used with a damping member which has a tubular configuration or the like. A damping member **20***b* of tubular configuration is shown in FIG. **10**. The pin **11** or **26** may also be undercut as shown in FIG. **10** so as to have a smaller diameter in the center than at the ends. In addition, the pin **11** or **26** need not have a circular cross section and, as an example, may have a cross section such as shown in FIG. **11** which will provide increased stress of the damping material for coil card movement in the vertical direction as viewed in that FIG. Further, no center pin **11** or **26** need be used. The damping member may be supported at its ends by the transducer housing or other means and, although the damping efficiency may be reduced, it may be sufficient for some applications. Finally, the damping as taught herein need not be applied to a transducer having the follower assembly **16** as shown in FIG. **1**, as an example, pin **11** or one similar may be secured rigidly to the transducer housing and mated with the damping member **20** as previously described or, of course, the pin **11** may be secured to a pivoted arm similar to arm **12** without the follower roller **14**. The aperture or hole **21** in the coil card and the associated damping structure may be located elsewhere on the coil card rather than at the location shown by FIG. **1**.

Therefore, while the invention has been disclosed and described in some detail in the foregoing description and drawings, they are to be considered as illustrative and not restrictive, as other modifications and variations will be apparent to those skilled in the art and within the scope of the invention, reference being made to the appended claims.

What is claimed is:

1. The improvement in a facsimile transducer of the moving coil type comprising:

first means defining two parallel surfaces; and

a coil card disposed between said surfaces and adapted for movement in a direction parallel to said surfaces, said card being provided with three raised portions adjacent each parallel surface, said portions providing a low and controlled friction between said card and said surfaces.

2. A facsimile transducer comprising:

a. means for providing a magnetic field;

b. first means movably disposed in said magnetic field;

c. second means responsive to movement of said first means for imprinting information on copy paper, said second means being directly coupled to said first means;

d. positioning means for establishing the relative position of said second means and a copy material; and

e. bearing means on said first means for positioning said first means in said magnetic field whereby the frictional forces between said first means and said magnetic field means are maintained at a low and uniform level independent of minor surface variations in said first means.

3. The transducer of claim **2** wherein said bearing means comprises three raised portions on each surface of said first means.

4. The transducer of claim **3** wherein said raised portions comprise three inserts.

5. An improved facsimile transducer comprising:

first means for creating a magnetic field;

second means movably disposed in said magnetic field and provided with an aperture; and

third means for damping the motion of said second means, said third means comprising a single damping member passing through said aperture.

6. An improved facsimile transducer comprising:

first means for creating a magnetic field;

second means movably disposed in said magnetic field, said second means being provided with an aperture;

third means for damping the motion of said second means, said third means comprising first and second members passing through said aperture, said first member isolating said second member from direct contact with said second means.

7. The improved transducer of claim **6** further comprising positioning means coupled to said second member for establishing the relative position of said second means and a copy material.

8. The improved transducer of claim **7** further comprising inertial means mechanically coupled to said second member and second damping means coupling said second member with said positioning means.

9. A facsimile transducer comprising:

a. means for providing a magnetic field;

b. first means movably disposed in said magnetic field;

c. second means responsive to movement of said first means for imprinting information on a copy paper, said second means being directly coupled to said first means;

d. positioning means for establishing the relative position of said second means and a copy material, wherein

e. said positioning means comprises damping means adapted to transmit relative position information and to not transmit undesired vibrations, said damping means further adapted to provide a damping of the motion of said first means throughout the extent of its travel.

10. The transducer of claim **9** further comprising bearing means for positioning said first means in said magnetic field.

11. The transducer of claim **9** wherein said damping means comprises a first member passing through an aperture in said first means, and a damping material in contact with both said first member and said first means.

12. The transducer of claim **11** wherein said damping material prevents said first member from directly contacting said first means.

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