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Curtiss

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[54] **VARIABLE RELUCTANCE TRANSDUCER**

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[52] **U.S. Cl.** .... **336/110,** 340/174.1 F, 340/174.1 H

[51] **Int. Cl.** **H01f 21/00**

[58] **Field of Search** ..... 336/110; 101/93 C; 235/611 D; 340/174.1 F, 174.1 H

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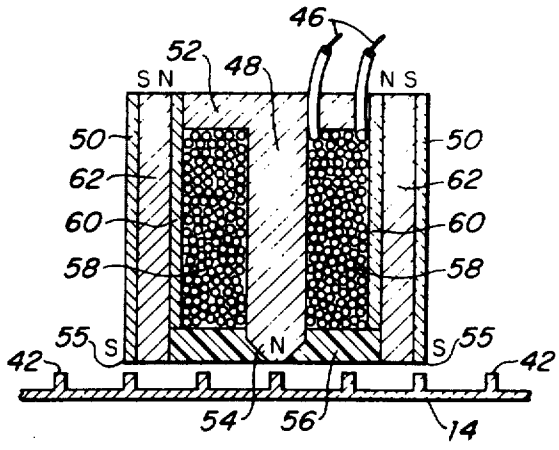
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[57] **ABSTRACT**

A variable-reluctance transducer for sensing control indicia that are directly formed on a type carrier. The transducer contains an axial pole and a concentric cylindrical pole, in which are located a coil and a cylindrically-shaped magnet.

4 Claims, 4 Drawing Figures



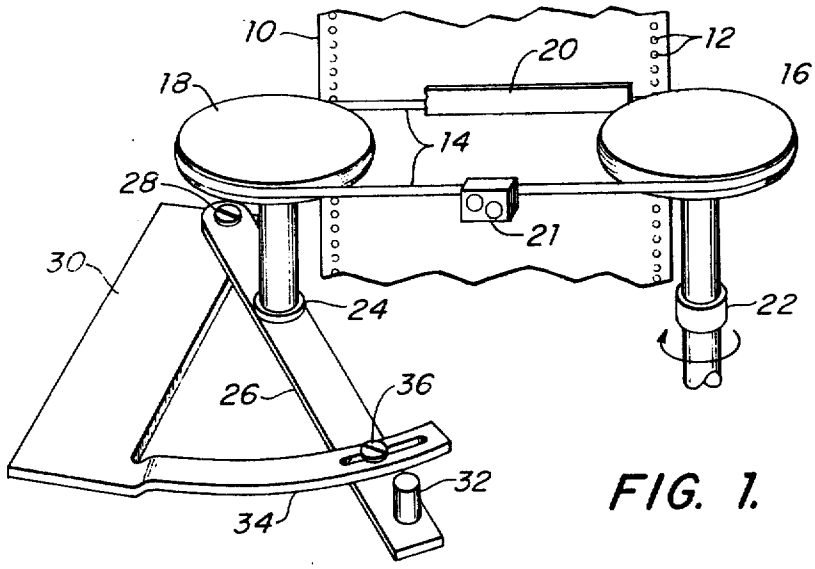


FIG. 1.

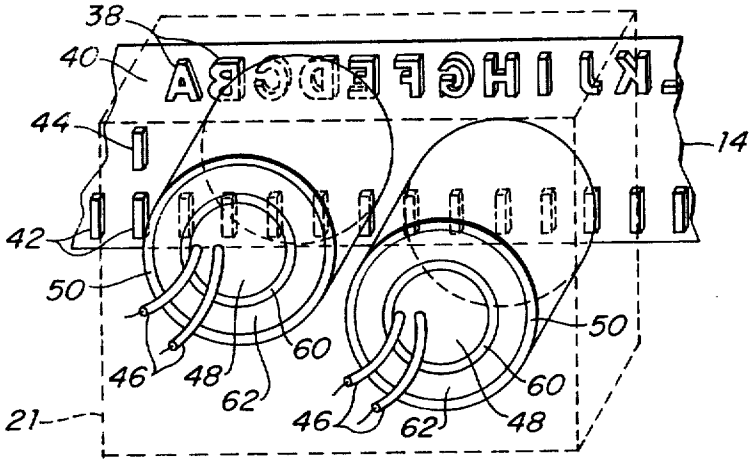


FIG. 2.

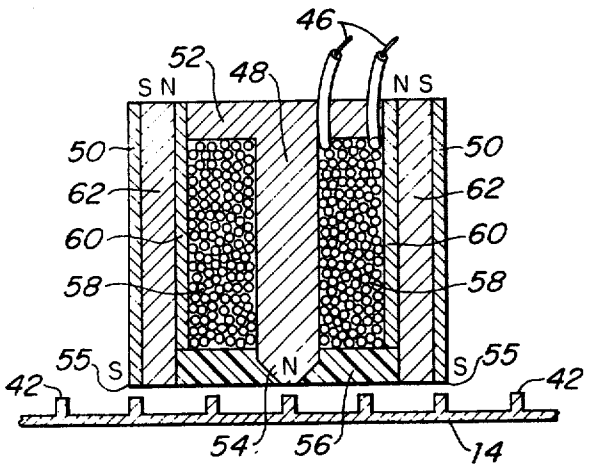


FIG. 3.

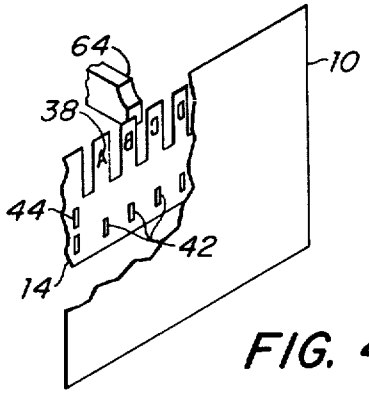


FIG. 4.

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VARIABLE RELUCTANCE TRANSDUCER

BACKGROUND OF THE INVENTION

High-speed, on-the-fly printers have employed type carriers of the kind which move across the document along the line to be printed while print hammers are selectively actuated. These devices generally contain type slugs which are clamped or otherwise mounted on a flexible carrier such as a timing belt. Alternatively, a train of type can be guided along a specially constructed track and a supporting carrier is not required. In another form of type carrier, a steel band contains raised characters which are produced by an etching or other metal-working process. Still other printers employ type drums or type wheels having one or more columns of type, each column containing a font of type distributed around the periphery of the drum or wheel.

The precise location of the type must be constantly monitored while the type carrier is in motion in order to precisely time the actuation of the print hammers. Various forms of position-sensing transducers have been used, including optical, magnetic, capacitive and reluctance sensing devices. These transducers have generally operated on indicia located either on the type carrier drive mechanism or on a separate indicia carrier which moves in coordination with the motion of the type carrier.

Variable-reluctance transducers have generally been constructed with bar-shaped magnets, limiting the arrangement of their pole pieces. These transducers produce relatively weak pulses that are generally unreliable for sensing the position of a type carrier unless the type carrier moves at a relatively high rate of speed.

BRIEF DESCRIPTION OF THE INVENTION

The present invention is embodied in conjunction with a type carrier having type which is etched or otherwise formed on a band of steel. The band is then welded together at its ends to form a closed loop. Since the type and the carrier are formed from a homogeneous material, the band is sturdy and the type is permanently and accurately located on the band. The band contains not only type elements, but also control indicia which are precisely located with respect to the type and are formed while the type is being formed.

The control indicia are sensed while the band is in operation and pulses are produced which control the operation of the printer. Great accuracy and reliability of operation is obtained by the use of the inventive transducer as it produces pulses having relatively large amplitudes and steep slopes.

In the inventive transducer, one pole piece is a ferromagnetic rod which supports a coil of wire. The coil is surrounded by a sleeve of ferromagnetic material. The sleeve is surrounded by a cylindrical magnet which is radially polarized and the entire structure is surrounded by a cylindrically-shaped ferromagnetic outer pole. Preferably, the distance between the center pole and the outer pole is an integral multiple of the distance between control indicia on the band. The transducer is located adjacent to the band and, as the control indicia move past the poles, a change in reluctance of the magnetic path produces an electrical voltage across the coil, which in turn controls the operation of the printer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

The preferred embodiment of the invention is shown in detail in the drawings, where:

FIG. **1** is a functional diagram showing the band, its supports and the transducer assembly.

FIG. **2** is an enlarged isometric view of the transducer assembly and a portion of the band.

FIG. **3** is a cross-sectional view of a transducer, and

FIG. **4** is functional diagram of an alternate embodiment of the invention.

In the printer shown in FIG. **1**, a document **10** to be printed is stepped upward, a line at a time, by standard paper feed devices operating on marginal perforations **12**. Print hammers are located behind the document, one for each column to be printed. Suitable hammers are described in a U.S. Pat. No. 3,780,648, issued Dec. 25, 1973, filed on Sept. 2, 1969, by Robert H. Curtiss, Richard Holzman, and Seldan A. Lazarow, entitled Hammer for Impact Printer, and assigned to the assignee of the present invention.

The inventive type carrier consists of an etched band **14** supported by a drive pulley **16** and an idler pulley **18**. The pulleys are crowned to accurately maintain the band **14** in the appropriate vertical position. Alternatively, flanged pulleys may be used. The band contains raised type and control indicia to be described in detail below. A back-up plate **20** (shown partially cut-away) extends along the printing line on the side of the band **14** that is opposite to the document. The back-up plate provides a solid bearing surface to prevent flexing of the band when the hammers strike the document against the type. A printing ribbon (not shown) is located between the document **10** and the band **14**.

The position of the band is sensed by transducers mounted in a housing **21** that is located adjacent to the carrier. The transducers sense the exact position of the type to provide control signals to time the actuation of the print hammers.

The drive pulley **16** is mounted for rotational movement in a bearing **22** and is driven at a constant speed by a motor (not shown). The follower pulley **18** is also mounted for rotational movement in a bearing **24** on an adjustable arm **26**. The arm is rotatable about a pivot **28** on a portion **30** of the printer frame. The position of the arm **26** is manually adjusted with a handle **32**. When the arm is properly adjusted, it is held firmly to a slotted extension **34** of the frame by tightening a locking screw **36**.

The band **14** is removed by moving the arm **26** toward the right until the band can clear the pulleys. The arm **26** also permits the tension on the band to be adjusted.

The mounting and adjustment of the band are shown functionally by simple apparatus because there are many well-known structures that are suitable for driving a steel band.

The band **14** and the transducer housing **21** are shown in greater detail in FIG. **2**. Raised type **38** are aligned in a row at a pre-determined distance from an edge of the band. The type is preferably located as close as possible to the upper edge of the band so that the resultant printing can be viewed while the next line, or the line thereafter, is being printed. Two or more rows of type can be formed on one band if desired. For example, a row of type can be formed near each edge

of the band and the band reversed in position on the pulleys when it is desired to change from one row of type to the other. Alternatively, the entire pulley assembly can be raised and lowered to select a row of type.

In the preferred embodiment of the invention, the band is **48** inches long, containing six fonts of **63** type characters spaced on one-eighth inch centers with a blank space **40** between each font of type. Raised, elongated control indicia **42** are aligned in another row along the length of the band, where each control indicia corresponds to a type element (or to the space between type elements) and is located along the band at precisely the same position as the center of the corresponding type element. Along another row on the band is a single control indicia **44** for each font of type on the band. These indicia are located to correspond to the blank spaces **40** between fonts. The use of two rows of control indicia permits standard printer circuitry to establish the identity and position of each character along the printing line.

A single row of control indicia can also be employed, where a control indicia corresponds to each type element along the band except for one position in each font (such as the position corresponding to the blank space **40.** The printer circuitry is modified to recognize a new font by the absence of a pulse at the anticipated time instead of by an additional pulse.

The band **14** is constructed of magnetic stainless steel and is approximately 0.005 inch thick. The type elements and control indicia are raised about 0.010 inch to provide a total thickness of about 0.015 inch. The band is preferably formed by etching magnetic stainless steel stock of the appropriate thickness. Standard etching techniques are suitable, such as applying a photoresist to the area which is not to be etched (corresponding to the type and control indicia) and carefully etching the remainder of the stock to the desired thickness.

The band is completed by welding the ends, preferably in the area of the blank spaces **40** between fonts. If the control indicia are destroyed in the area of the weld, a second transducer housing can be located exactly one font away from the first transducer housing so that pulses are provided by at least one set of transducers at all times.

The speed of movement of the band is determined by the length of a type font on the band and the desired printing speed. In the preferred embodiment, each font is eight inches long and a line is printed in about 0.25 seconds, so the band moves at a speed of about 32 inches per second.

While standard reluctance-type transducers can be used to sense the control indicia, higher signal levels and greater system stability are achieved using the transducers shown in FIGS. **2** and **3.** As shown in FIG. **2,** two transducers are mounted in the housing **21,** one transducer is aligned with each row of control indicia to produce an electrical signal on its conductors **46** when a control indicia is centered beneath the transducer.

In the cutaway view of FIG. **3,** the transducer contains an elongated center pole piece **48** and a cylindrical outer pole piece **50.** The center pole piece is tack-shaped, containing a circular, disk-shaped portion **52** at one end and terminating in a pole **54** at the other end. The pole **54** is chisel-shaped with a tip that conforms to the shape of the control indicia. The outer pole piece **50** terminates in a circular pole **55.** The disk-shaped portion **52** of the center pole piece **48** contains openings for the conductors **46.** Both poles **48, 50** are constructed from soft-ferromagnetic material, such as iron. A non-magnetic support **56** surrounds the pole **54** to provide a form to support a coil of insulated wire **58,** terminating in the leads **46.**

The overall size of the transducer is not critical, but is preferably about 0.5 inch in diameter and about 0.5 inch in length. About 1,000 turns of wire are used to form the coil.

The coil is surrounded by a ferromagnetic sleeve **60** which is preferably shorter in length than pole piece **48.** A cylindrical permanent magnet **62** is located between the sleeve **60** and the outer pole piece **50.** The magnet is shown with a length equal to the length of the pole pieces **48, 50,** but may be shorter: eg, the length of the sleeve **60.** The magnet is radially polarized to provide north (N) and south (S) poles as indicated on the drawing (or opposite to the indication on the drawing). The magnet is preferably of the type known as a "rubber magnet" which employs powdered barium ferrite vulcanized in rubber. Since the sleeve **60** abuts the disk-shaped portion **52** of the center pole piece, the arrangement produces two poles, **54, 55,** enclosing the magnet and coil. In effect, the center pole piece **50** and the sleeve **60** form a single pole piece and can be constructed from a single piece of material.

Alternatively, the coil can be wound on a separate spool-shaped form which fits around the elongated portion of the center pole piece **48.** In this case, the support **56** is not required.

This configuration of the transducer produces pulses which have a high amplitude for several reasons. The pole pieces are arranged to avoid undesirable flux leakage while concentrating the flux density in the region of the control indicia which are to be sensed. The arrangement of the coil insures that flux changes caused by the passage of the control indicia link all turns of the coil. Furthermore, the cylindrical magnet has a relatively large area contacting the pole pieces to produce a large magnetic field.

The transducer is shown in its relationship to the control indicia **42** on the band **14.** The distance between the poles **54, 55** equals approximately 0.25 inch which is equal to double the distance between control indicia **42.** Thus, the overall transducer covers five control indicia when pole **54** is centered on one of the indicia. The reluctance of the path between the poles depends upon the location of the carrier and is lowest when the control indicia are centered as shown in FIG. **3.** As the indicia move past the transducer, a pulse of current is generated in the coil as a function of the change in reluctance between the poles **54, 55.**

While the distance between the poles is not critical, it is preferably an integral multiple of the distance between control indicia, as shown in FIG. **3.** In this case, the reluctance change is greatest when the control indicia pass the transducer. Since the effect of control indicia passing the outer pole **55** is much less than the effect upon the inner pole **54** (because the outer pole is circular and is adjacent to the carrier **14** about a much larger area than the small center pole), the transducer will perform satisfactorily even if the distance between poles is not an integral multiple of the distance between control indicia. For this reason, the transducer produces a sufficient output when used to sense the font

indicia (in the center of the carrier), even though there are no indicia present near the outer pole **55** when the font indicia is beneath the center pole.

Another configuration of the transducer employs a forked center pole piece terminating in two (or more) chisel pointed poles. The distance between the poles equals the distance between the control indicia which are to be sensed. With this configuration, considerably larger pulses are generated as two (or more) indicia are simultaneously sensed and, even in the event that an indicia is missing (as may occur at the weld), the transducer will still supply a pulse, although of lesser amplitude. This feature can be advantageously employed with a single row of control indicia, omitting one indicia at a predetermined position for each font and detecting the relative amplitudes of the generated pulses to provide a font indication.

An alternate embodiment of the invention is shown in FIG. **4**, where print hammers **64** and a band **14** are arranged on the same side of the document **10**. In this embodiment, the band is further etched through its entire thickness between type elements to form a comb-shaped carrier with type arranged on the fingers of the comb. The control indicia **42, 44** and transducers are similar to the indicia described with respect to the embodiment of FIGS. **1, 2** and **3.**

In the above-described embodiments of the invention, the transducer and its component parts are shown and described with the shape of a right circular cylinder. While this shape provides for simplicity of construction, other forms of cylinders can be employed. For example, the transducer can be constructed with a square or rectangular cross-section and the sides of the transducer need not be perpendicular to the sensing surface. Regardless of the type of cylinder, optimum performance is achieved when the components of the transducer are concentric; eg, the centers of the outer pole and the magnet coincide with the center of the inner pole.

What is claimed is:

1. A transducer for sensing the passage of moving spaced indicia comprising, in combination:

A first pole piece of ferromagnetic material having an elongated portion terminating in a pole at one end, having a flat portion at the other end of the elongated portion, and having a cylindrically-shaped portion projecting from the periphery of the flat portion in a direction parallel to the elongated portion;

a coil of electrically-conducting material surrounding at least part of the elongated portion of the first pole piece;

a radially-polarized, cylindrically-shaped sleeve of permanent magnetic material surrounding the cylindrical-shaped portion of the first pole piece;

and a second pole piece of ferromagnetic material having a cylindrical shape, having a length substantially equal to the length of the elongated portion of the first pole piece, surrounding the magnetic sleeve, and terminating in at least one pole at the end nearest the pole of the first pole piece.

2. The transducer described in claim **1**, wherein the distance between the poles of the first and second pole pieces is an integral multiple of the distance between adjacent indicia to be sensed.

3. The transducer described in claim **1**, wherein the pole of the first pole piece has a shape dependent upon the shape of an indicia to be sensed.

4. The transducer described in claim **1**, wherein the flat portion of the first pole piece is substantially perpendicular to its elongated portion and wherein all cylindrically-shaped elements have the shapes of right circular cylinders.

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