United States Patent

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[54] **MAGNETICALLY ENGAGED ROLLERS FOR CARD TRANSPORT**
4 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **271/51,** 271/80
[51] **Int. Cl.** **B65h 5/06,** B65h 7/08; F16h 55/18
[50] **Field of Search** .... 271/51, 80; 226/(Inquired); 74/409, Magnetic, 440

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ABSTRACT: A card transport for moving cards accurately but without creasing them, comprising several pairs of pinch rollers between which the cards move. Each pair of pinch rollers includes a driven roller which is a permanent magnet and an idler roller constructed of soft iron, so they remain in contact by magnetic attraction until a card passes through. In a first pair of rollers, the driven and normally idler rollers are connected by gears, and backlash is eliminated from the gears by constructing one as a permanent magnet and the other of soft iron.

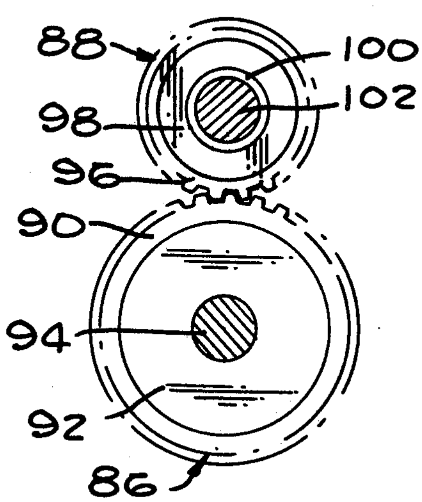

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Fig. 1

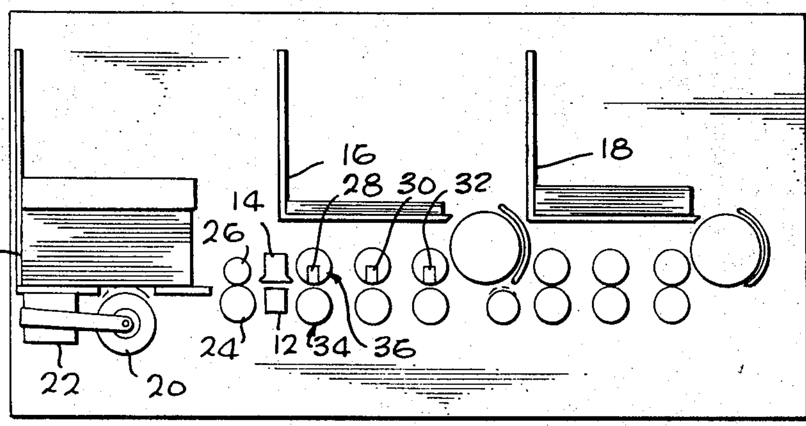


Fig. 2

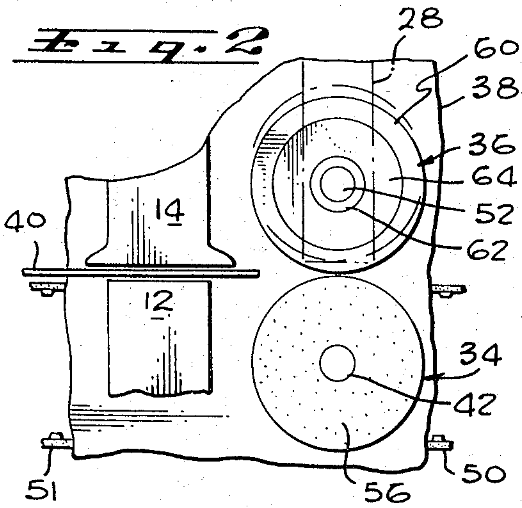


Fig. 4

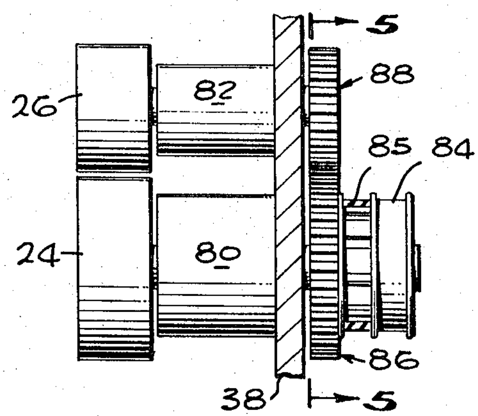


Fig. 3

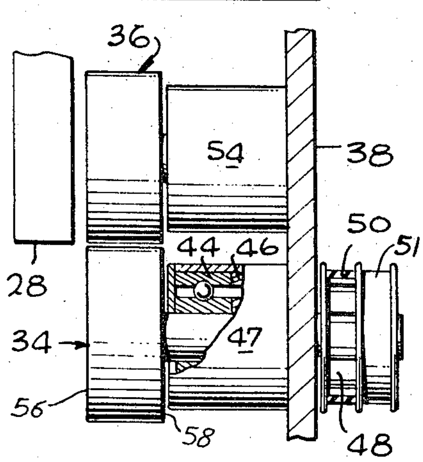


Fig. 5

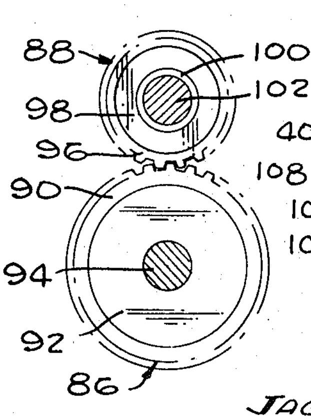
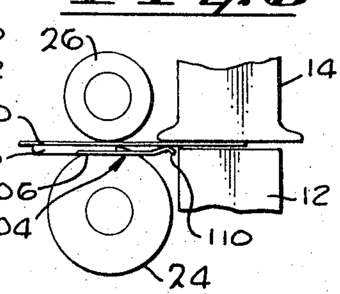


Fig. 6



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MAGNETICALLY ENGAGED ROLLERS FOR CARD TRANSPORT

BACKGROUND OF THE INVENTION

This invention relates to rotating drive train mechanisms and especially to a drive train for a card transport.

High speed card transports are used extensively in data processing systems. Such transports typically provide mechanisms for receiving a stack of punched or marked cards and moving them one at a time from the stack, past optical readout heads, and into another stack. The transports generally move cards at a high rate such as 1500 cards per minute, and the markings are spaced close together along the length of the card, such as at 0.087 inch spacings. Accordingly, such transport apparatus must be capable of performance with high speed and accuracy.

Cards are moved through the transport by many pairs of pinch rollers. One roller of each pair is driven at high speed, while the other is an idler, and the cards pass between them. Accurate card movement requires that the cards be moved without creasing them, that they move without flapping, and that they do not cause vibrations in the apparatus. Transports available heretofore have had all three of these difficiencies.

Creasing of cards arises from high contact pressures of the rollers, the high contact pressures being employed to assure that both rollers of a pair rotate at the same speed. If the idler roller does not turn as fast as the driven roller, the card does not move in a straight line, and it bangs against the next transport elements, causing "jittering" outputs from the readout head. The rotation of the two rollers at the same speed is most easily accomplished by maintaining them with their perimeters in contact until a card passes between them. The rims are generally constructed of steel to increase durability. When a card passes through, the rollers must separate sufficiently to pass the card.

In order to allow for their separation, the rollers have often been built with inner cores of rubber within the rim of the rollers. It has been found that the steel-rimmed rollers must bear against each other with high pressures to assure that the idle roller moves as fast as the driven roller. However, it is found that these high contact pressures result in creases in the cards, which limit their useful life. It can be appreciated that the pressure of the rollers on the cards is even higher than the pressure of the rollers against each other when there is no card between them, since the rubber core is even more compressed when a card is passing through.

A means for pressing the rollers against each other with high forces when no card is passing through, but with only a small force when a card is passing through, would permit accurate card movement without creasing.

Flapping of cards in their passage through the transport is another problem encountered. It is found that repeated bending or flapping occurs even if the rollers turn at the same speed immediately prior to the passage of cards through them. This results in the card portion at the readout head moving back and forth, and gives rise to a double readout or a "jittering" readout signal. The occurrence of flapping limits the minimum spacing of marks on the card, and limits the maximum speed of the transport which can be employed while maintaining accurate readout.

High speed cameras have been used in attempts to discover the causes of flapping. They show that as the leading edge of the card passes the readout head and first enters between the following pair of rollers, the idler roller of the following pair slows down. The idler roller immediately speeds up again as the card is fully engaged between the rollers, but in the meantime the card has flapped. A means for keeping the rollers moving at exactly the same speed as a card entered between them would reduce flapping and thereby enable accurate readout to high densities at high speeds.

Large shocks and vibrations occur during the rapid acceleration of a card by the transport. A card transport generally includes a station for holding a stack of cards. A pick roller is moved against the bottom card in the stack to send one card at a time through a first pair of pinch rollers. While the rims of the first pair of rollers are pressed together, the rollers are also joined by gears to maintain them at the same speed. Gear engagement is required because of the very heavy load encountered in accelerating the card to full speed from the intermediate speed imparted by the pick roller.

When the card enters between the first pinch rollers, the heavy load on the rollers places a heavy load on the gears connecting them. The solid driven roller has a stiff connection to its gear, but the rubber-cored idler roller has a more flexible connection to its gear. Because of backlash, the gear teeth of the driven roller may slam against those of the idler roller. When this happens, a large shock occurs which vibrates the entire machine. The vibrations still exist when the card begins its passage through the read head, and this can also lead to a jittering output. If the backlash between the gears could be substantially eliminated, the vibrations would be reduced considerably.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide a card transport for moving cards without creasing them.

Another object is to provide a high speed card reader capable of reading cards with greater reliability than card transports available heretofore.

In accordance with the present invention, a card transport is provided which uses pairs of pinch rollers to move cards. One roller of each pair is driven and the other is an idler, but they rotate at the same speed because their rims are in firm engagement until a card passes through. The firm engagement is achieved by constructing a first of the rollers of permanent magnet material and constructing the second roller so it is magnetically attracted to the first. When a card passes through, the edge of the card separates the rollers, and the separation reduces the magnetic attraction of the rollers. Accordingly, a relatively low pressure is exerted on the card, and this prevents creasing of the card.

As a card enters between the magnetically attracted rollers, the idler roller does not undergo a temporary decrease in speed. As a result, flapping of the card is eliminated. It is believed that the magnetic field, which passes through the paper cards, keeps the rollers moving at the same speed.

A first pair of rollers which receives a card from the stack is connected by a pair of gears. The gears prevent excessive slowing of the idler roller under the heavy load of accelerating a card to full speed. Backlash in the gears is substantially eliminated by constructing one gear as a permanent magnet and the other from soft iron. The magnetic attraction maintains the gears in contact without any spacing, thereby eliminating backlash. This construction substantially reduces the vibrations set up as each card begins its passage through the transport.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a card transport constructed in accordance with the invention;

FIG. 2 is a partial plan view of the card transport of FIG. 1 showing a pair of pinch rollers thereof;

FIG. 3 is a side elevation view of the rollers of FIG. 2;

FIG. 4 is a partial side elevation view of the card transport of FIG. 1 showing a gear-connected pair of pinch rollers thereof;

FIG. 5 is a plan view taken on the line 5–5 of FIG. 4; and

FIG. 6 is a partial side elevation view of another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a card transport constructed in accordance with the invention, for reading out information from cards. The cards move one at a time from an input stack holder **10**, past a pair of readout heads **12** and **14**, and into output stack holders **16** and **18**. A pick roller **20** removes one card at a time from the bottom of the input stack, when a solenoid **22** presses the pick roller briefly against the stack. The card passes between a first pair of pinch rollers **24** and **26**, then between the readout heads **12** and **14**, and then between additional pairs of rollers to one of the output stacks **16** or **18**.

An appreciation of the requirement for accurate card movement can be had by considering the manner of readout of information from the cards. The cards may have marks such as small dots, and each readout head includes means for projecting a light beam at the card and detecting any reflected beam. The two heads allow the readout of information carried on both sides of the cards. The marking area on each side of a card is divided into a large number of columns and rows, such as 80 columns along the length of the card, and 31 rows along its width. Each readout head has a read opening for each row, so that there are 31 read openings for cards with 31 rows.

When the leading edge of a card passes the heads **12** and **14**, a timing period begins. After a predetermined period on the order of milliseconds, the card should have moved to a position where the center of the first column on the card is under the read openings in the heads. The readout at that time is taken to be the information recorded in the first column. After each period of time which is required for the card to move one column, a new readout is taken. Leading edge sensors **28**, **30** and **32** are positioned on the transport at intervals equal to the distance between a predetermined number of columns, such as about 25. The sensors determine whether the card is ahead or behind in speed, and slightly advance or delay the time of readout of the columns passing under the readout heads. Whether or not the readout is taken near the center of each column and, in fact, whether the right column is being readout, depends upon accurate movement of the cards. The cards must move at the desired speed and undergo a minimum of bending until the last column of the card passes the readout heads.

The accurate travel of the cards between the readout heads depends upon the pairs of pinch rollers which move the cards. The first pair of pinch rollers **24** and **26** must accelerate the card from an intermediate speed imparted by the pick roller **20**, to the final speed. The pick roller cannot be depended upon to accelerate the card to final speed because of slippage. After the card passes by the heads, it is moved by a series of additional pinch rollers, such as the pair **34**, **36**. The head, rollers, and other components are mounted on a base plate **38**, and motors for driving the rollers are mounted under the plate.

FIGS. 2 and 3 illustrate the driven roller **34** and idler roller **36**, which move a card shown at **40** after passage between the readout heads **12** and **14**. The driven roller **34** is mounted on a drive roller shaft **42** which projects through the support plate **38**. The drive roller shaft is rotatably supported on a pair of bearings **44** and **46** in a pillow block **47** which is mounted on the support plate. A geared pulley **48** mounted on the drive roller shaft is driven at a high speed by a geared belt **50**. Another belt **51** extends to the next drive roller of the next pair of pinch rollers, to drive it. The idler roller **36** is mounted on an idler roller shaft **52**. The idler roller shaft is rotatably supported on a pair of bearings in a pillow block **54** which is mounted on the support plate.

A card **40** is moved through the rollers by insertion between them after passage through the readout heads. When a card is not between the rollers, their rim portions are engaged so that the driven roller **34** drives the idler roller **36**. This results in their peripheries moving at the same speed. Movement of the rollers **34** and **36** at the same speed is necessary for accurate guidance of a card **40** through the rollers. If the driven roller **34** moves at a greater speed than the idler roller **36**, the card **40** will tend to curl about the idler roller **36**. This is due to the fact that that face of a card which is in contact with a higher speed roller will tend to move faster than the other face, thereby bending the card toward the slower roller. Even if the card bends, it can generally be guided into the next pair of pinch rollers. However, the bending will cause its leading edge to be delayed in passing the next leading edge sensor (shown at **30** in FIG. 1) and the readout heads will not read accurately. That is, the readout head will be commanded to delay the readout of succeeding columns more that it should be delayed.

An important feature of the invention is the fact that the driven roller **34** is constructed of a cylinder of permanent magnet material, such as Alnico, and is magnetized with its opposite ends **56** and **58** of opposite magnetic polarity. The idler roller **36** is constructed of several different portions for enabling it to be magnetically attracted to the driven roller, and yet allow it to move away from the driven roller to pass a card **40** between them. The idler roller has a rim portion **60** of soft iron, a hub portion **62** of steel, and a core portion **64** of rubber. The soft iron of the rim portion **60** facilitates attraction to the magnetized driven roller **34**. The rubber of the core portion **64** allows the rim portion **60** to move toward the driven roller when there is no card between them, and to move away from the driven roller when a card is inserted between them. Such movement is accomplished without movement of the idler roller shaft **52**. The hub **62** serves to firmly connect the core portion **64** to the shaft **52**.

Before a card passes between the rollers **34** and **36**, their rims bear against each other with high pressure. This is due to the fact that magnetic attraction varies with separation of the attracting bodies, and is strongest when they touch. The high pressure assures that the idler roller **36** rolls at the same speed as the driven roller **34**, even when the card transport is started and the driven roller is rapidly brought up to speed. The idler roller has a high moment of inertia and is difficult to bring up to speed. If considerable sliding of the roller rims occurred, considerable wear would result.

When a card begins to pass between the rollers, the leading edge of the card separates them by the width of the card, a typical card being seven thousandths inch thick. At such a separation, the attraction of the rollers is considerably less than it is at contact. Thus, the rollers do not bear hard on the card as it passes through. The reduced pressure prevents the development of a crease along the card where it contacts the edges of the roller rims. Such creasing often occurred in prior systems where the high contact pressure was maintained (and even increased) when a card passed between the rollers.

The magnetic attraction of the rollers helps to maintain them at the same speed even when they are separated. This reduces bending of the card as it enters between the rollers. High speed camera studies have shown that when the card first enters between the rollers, the rollers may slow down slightly until the card is fully engaged. During this period, the idler roller may slow down more than the driven roller, and this causes additional bending. With the magnetic construction described above, the temporary difference in speed is greatly reduced, and bending is reduced. It is believed that this is due to the tendency of the magnetized roller to keep the other roller moving even when they are not in physical contact, in much the same way as a motor armature and field coil interact to rotate the armature.

The bearings for supporting the driver roller shaft **42** and idler roller shaft **52** may be positioned a distance apart which provides a small clearance between the rollers **34** and **36**. The magnetic attracting force between the rollers, and the elasticity of the rubber core portion **64** are of a value which allows the idler roller **36** to shift its position slightly until its rim touches the rim of the driven roller **34**. However, the rollers are typically positioned so they would have zero clearance in the absence of magnetic attraction. The core portion is stressed when a card of perhaps seven thousandths inch passes through, but the core can be of a very pliable material (low modulus of elasticity) and low stresses are encountered. The bearings which support the rollers are only lightly stressed when a card is not between the rollers, and only moderately stressed when a card is passing through.

The rollers can be constructed in many different configurations. For example, the permanent magnet of the driven roller can be magnetized with its center and rim portions of opposite polarity. For greater attraction, the idler roller can also be constructed of permanent magnet material. This construction is advantageous where no rubber core material is required. Some rubbery core materials are even available which can serve as a permanent magnet material.

The first pair of pinch rollers shown at **24** and **26** in FIG. **1** are subject to especially large loads. This is because the cards are not moving at the peripheral speed of the rollers when they enter between the rollers. In the case of the other pairs of rollers, the cards are moving at practically the proper speed and the rollers must merely maintain this speed. To enable the first pair of rollers **24** and **26** to withstand the load of rapidly accelerating the cards to full speed, they are joined by a pair of gears. This supplements the engagement provided by the magnetic construction described above.

FIG. **4** is a side view of the first pinch rollers **24** and **26**. The rollers are similar to the rollers **34** and **36** shown in FIGS. **2** and **3**, with roller **24** being an Alnico magnet and roller **26** having a rim of soft iron and a core of rubber. Also, they are supported on pillow blocks **80** and **82** which are mounted on the base plate **38**. One roller is driven by a gear belt **84**, and it drives another belt **85** which rotates the next roller **34** on the transport. Unlike the other rollers, however, the rollers **24** and **26** are connected together by gears **86** and **88**.

The gears **86** and **88** are used to prevent excessive slippage between the rollers **24** and **26** which might occur in suddenly accelerating a card from the speed imparted by the pick roller to full speed. While the gears prevent differences in roller speed, they have heretofore created shocks. The shock waves traveled through the base plate to the read heads and disrupted readout. The shock occurs when the rollers first grasp a card. As the card is grasped, the first roller **24** is suddenly slowed, and its gear **86** is similarly slowed. However, the shaft of the second roller **26** is more flexibly coupled to its gear **88** and there is a delay before the gear **88** is slowed. The temporary difference in gear speed heretofore resulted in the gear teeth banging into firm engagement. The banging was due to backlash which allows one gear to rotate an angle of perhaps 1° before it contacts a tooth of the other gear.

Backlash between the gears **86** and **88** is substantially eliminated by constructing them so that they magnetically attract each other, in a manner similar to that of the pinch rollers described above. As shown in FIG. **5**, gear **86** comprises an outer or rim portion **90** of steel, and a core **92** constructed of a permanent magnet material such as Alnico. The shaft **94** is fixed to the core portion. The other gear **88** is constructed with a rim portion **96** of steel or soft iron, a core portion **98** of rubber, and a hub portion **100** of steel. The hub portion is fixed to the shaft **102**. The magnetized core **92** of the gear **86** causes its rim **90** to attract the rim **96** of the gear **88**. The magnetic attraction between the gears **86** and **88** keeps them in close contact, so there is no space between the meshing teeth, and backlash is substantially eliminated.

The rubber core portion of gear **88** helps it to move into firm engagement with the gear **86**. The cantilevered shaft can provide sufficient flexibility to eliminate the rubber core, if the gear teeth are accurately formed so that very little displacement is required. The reason for the use of the rim portion on the gear **86** is to facilitate formation of the gear teeth, since some of the best magnetic materials, such as Alnico, are difficult to machine.

The use of a magnetic construction to prevent backlash is useful in a variety of applications, particularly in precision machinery to adjust the position of machine components. Irregularities in turning the gears due to the making and breaking of contact between gear teeth can be reduced by utilizing gears of fine pitch or by utilizing spiral gears.

FIG. **6** illustrates another embodiment of the invention which employs a spring **104** for further reducing jittering. The spring **104** is formed from a flat sheet of spring metal and contacts the card **40** along most of the card width. One end **106** of the spring is attached to a bottom plate **108** of the input stack holder, while the other end **110** bears against one head **14**. The spring biases cards against one side of the card path, and is located up-path from the heads between the first pinch holders **24**,**26**, and the heads. By using a sheet of 0.005 inch thick spring steel, jittering was reduced to an extremely low level.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art, and, consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.

I claim:

1. A magnetic drive comprising:
 - a pair of rotatable members having rim portions formed with gear teeth, said rim portions adjacent to each other;
 - one of said members comprising magnetized permanent magnet material and the other member comprising a material which is magnetically attractable, whereby to urge the rim portions of said members toward each other to reduce backlash; and
 - a pair of rollers coupled to said rotatable members at least one of said rollers being mounted for resilient movement toward and away from the other roller.

2. A card transport comprising:
 - means defining a card path;
 - a pair of pinch rollers disposed along said path for passing cards between them;
 - means for urging said rollers toward each other with a first force when the rims of said rollers are in contact and with a lesser force when said rims are separated;
 - means for holding cards located at one end of said path;
 - means for removing one card at a time from said means for holding cards and delivering them to said pinch rollers; and
 - a gear train connecting said pair of rollers, including a first gear having a portion of permanent magnet material which is magnetized and a second gear engaged with said first gear, said second gear including a portion of magnetically attractable material, whereby to decrease backlash.

3. Transport apparatus for moving material along a predetermined path comprising;
 - a first roller having a rim portion disposed along said path;
 - motor means coupled to said first roller to rotate it;
 - a second roller disposed along said path opposite said first roller, said second roller having a rim portion adjacent to the rim portion of said first roller to move material between them; and
 - one of said rollers being constructed of a permanent magnet material and the other being constructed with a core portion of elastomeric material and a rim portion of a magnetically attractable material for magnetic attraction to the roller which is of permanent magnet material, to maintain the rim portions of magnet material and of magnetically attractable material in direct contact with each other until material to be moved separates them.

4. Transport apparatus for moving material along a predetermined path comprising:
 - a first roller having a rim portion disposed along said path;
 - motor means coupled to said first roller to rotate it;
 - a second roller disposed along said path opposite said first roller, said second roller having a rim portion adjacent to the rim portion of said first roller to move material between them; and
 - wherein one of said rollers is constructed of a permanent magnet material and the other has a radially inner core portion of elastomeric material and a rim portion of soft iron for directly contacting the roller which is of permanent magnet material.