July 8, 1969 P. J. ICENBICE, JR., ET AL 3,454,956

CARD PRINTER

Filed Jan. 18, 1968 Sheet 1 of 2

Fig. 1

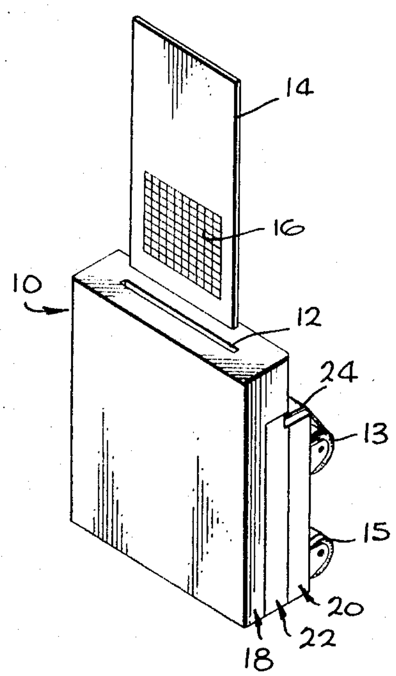


Fig. 3

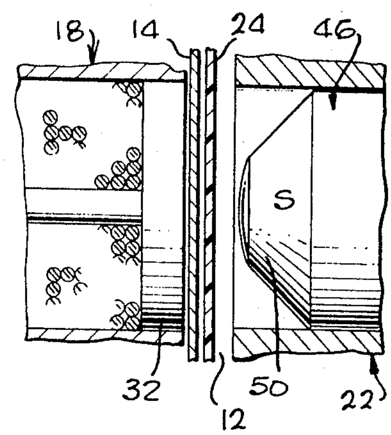
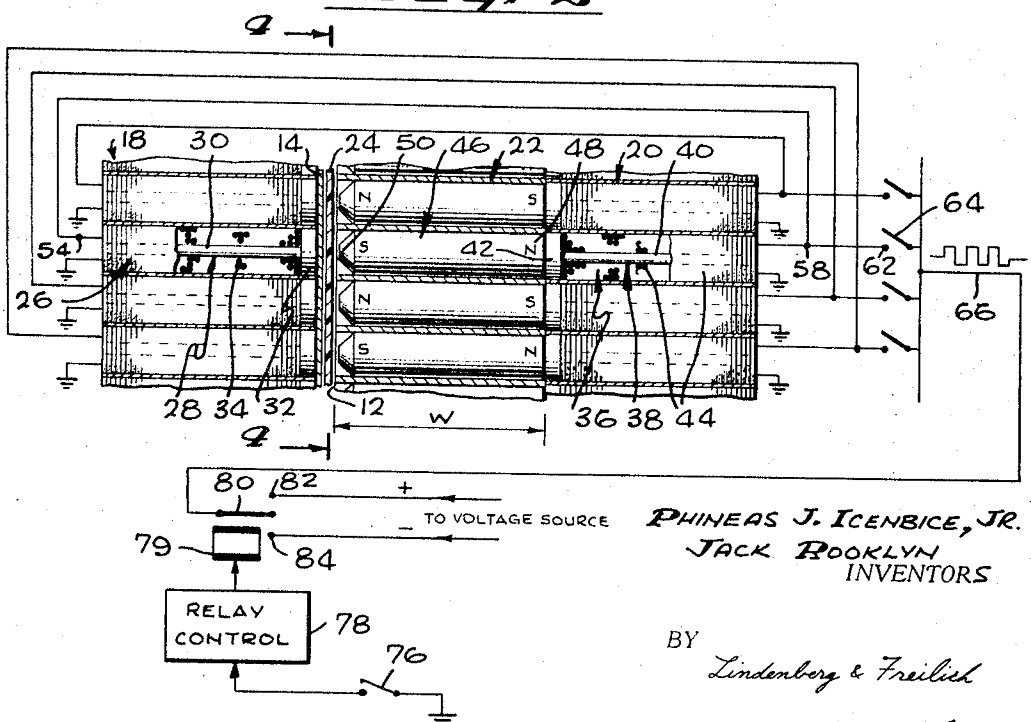


Fig. 2



PHINEAS J. ICENBICE, JR.
JACK ROOKLYN
INVENTORS

BY Lindenberg & Freilich

ATTORNEYS

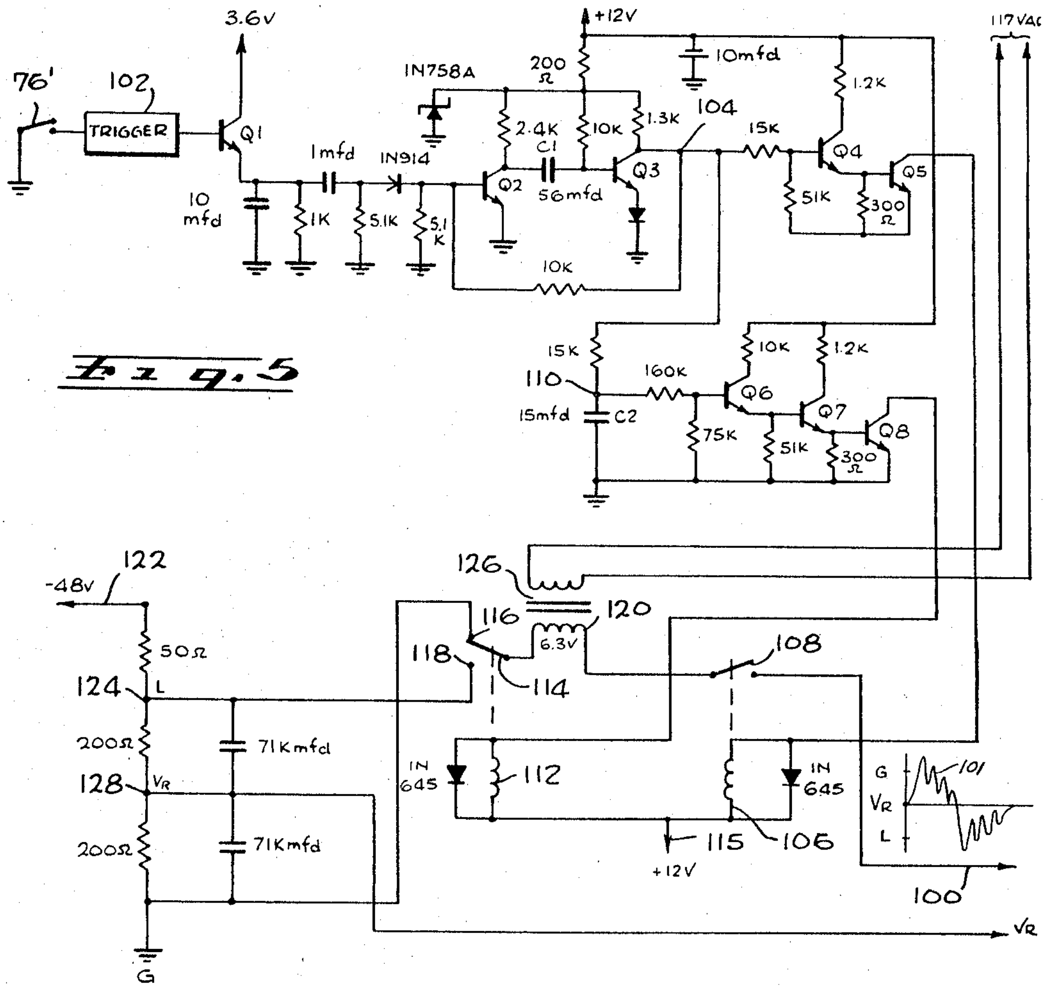


Fig. 5

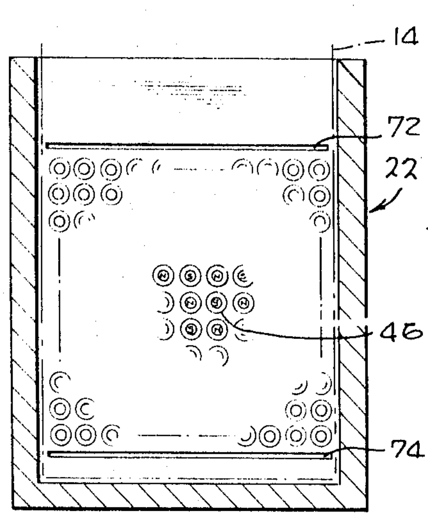


Fig. 4

PHINEAS J. ICENBICE, JR.
JACK ROOKLYN
INVENTORS

BY Lindenberg & Freilich
ATTORNEYS

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CARD PRINTER

Phineas J. Icenbice, Jr., and Janck Rooklyn, Altadena, Calif.; said Rooklyn assignor to Republic Corporation, Beverly Hills, Calif., a corporation of California

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ABSTRACT OF THE DISCLOSURE

Card printing apparatus comprising a multiplicity of closely spaced, rod-shaped plungers which can be individually activated so that their marking ends strike a ribbon against the card to mark it. Each plunger is a permanent magnet, and each is propelled by a separate pair of solenoids facing the opposite ends of the plunger. The solenoids are energized so one magnetically attracts while the other magnetically repels the plunger to move it toward the card or to move it back from the card. The plungers are arranged so that the marking ends of adjacent plungers are of opposite magnetic polarity to assure that the plungers move separately.

Background of the invention

This invention relates to printing apparatus and, more particularly, to apparatus wherein a marking mechanism is moved toward the material to be marked.

In many printing applications, it is necessary to independently actuate a number of closely spaced printing mechanisms. One such application is in certain telephone billing apparatus, wherein a card is positioned in a printer and the ten digit number which has been called is recorded by printing ten dots on the card. The printing apparatus includes 100 plungers and requires 100 separate plunger operating mechanisms. Relatively small cards, such as standard "IBM cards" which are 3¼ inches by 7⅜ inches are used, and therefore the plungers must be closely spaced, for example, at quarter-inch centers.

In the foregoing billing apparatus, an inked ribbon is utilized to print the dots, and a dot is printed when a plunger strikes the ribbon. Mechanisms used heretofore for moving plungers generally included a plunger of soft iron extending through the core area of a solenoid. Energization of the solenoid moved the plunger in one direction and a spring returned the plunger when the solenoid was de-energized. In order to move the plunger rapidly to assure clear printing, a large solenoid was used. However, such large solenoids cannot fit in the small space available when large numbers of plungers must be positioned close together.

The construction of a narrow-diameter plunger can be accomplished using the conventional plunger which moves within a hollow solenoid, by using a very long solenoid and activating it with large currents. However, resort to such measures is limited by heating, space limitations, and the greatly increased costs which they give rise to. An efficient mechanism for the independent activation of a large number of closely spaced solenoids, which moved the plungers with sufficient force to provide clear printing, would be useful in card printing mechanisms and a variety of other applications.

Summary of the invention

Accordingly, one object of the present invention is to provide economical printing apparatus for marking cards at any of a large number of closely spaced locations.

Another object is to provide a plunger activating mechanism which occupies a smaller space than those available heretofore.

In accordance with the present invention, there is provided a card printer comprising a multiplicity of closely spaced plungers, which can be independently moved toward the card to mark it. Each plunger is a permanent magnet, and is moved by a solenoid which attracts or repels it to move it toward or away from the card. A marking end of the plunger strikes a ribbon and presses it against the card to print a character such as a dot on the card.

Each plunger has the shape of a rod and is constructed of permanent magnet material, with its marking end and back end of opposite magnetic polarity. The plunger is held in a tube of non-magnetic material, which guides it in sliding toward and away from the card. A separate pair of electro-magnets, or solenoids, is provided to move each of the plungers. One solenoid is located on the side of the card opposite the front or marking end of the plunger, and the other solenoid is located opposite the rear end of the plunger. The two solenoids are simultaneously energized, so that when energizing currents flow in one direction, one solenoid pulls the plunger and the other pushes it toward the card. When currents flow through the solenoids in the opposite direction, one solenoid pushes the plunger away from the card while the other solenoid pulls it away.

The matrix of closely spaced plungers is arranged so that the marking ends of adjacent plungers are of opposite magnetic polarity. It has been found that this prevents a group of plungers from moving together when the solenoids of only one of them has been energized.

Each pair of solenoids can be constructed with a small diameter and moderate length. Yet, with even moderate currents, the solenoids move the plunger with considerable force to provide clear printing. The permanent magnet construction of the plunger provides a high strength magnetic field in a small space. The magnetic field is considerably greater than ordinarily can be achieved by an electromagnet of the same size, with the heat dissipation limitations encountered. The pair of solenoids provides two moderate strength magnetic fields for interacting with the strong permanent magnet field of the plunger, to propel the plunger with considerable force.

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

FIGURE 1 is a perspective view of a card printer constructed in accordance with the invention;

FIGURE 2 is a sectional view of a portion of the card printer of FIGURE 1;

FIGURE 3 is a fragmentary sectional view of the card printer of FIGURE 1;

FIGURE 4 is an elevation view of the card printer taken on the line 4—4 of FIGURE 3; and

FIGURE 5 is a schematic diagram of a circuit for supplying energizing currents to the card printer.

Description of the preferred embodiments

FIGURE 1 illustrates a card printer constructed in accordance with the invention, the card printer comprising a housing **10**, having a slot **12** for receiving the end of a card **14**. The card **14** has a printing area **16** thereon divided into 100 small boxes. After the card is inserted into the card printer **10**, ten dots are printed on the printing area to indicate the ten digits of a number which has been called by a telephone subscriber. Each dot is printed by a separate printing mechanism, and the card printer contains 100 such mechanisms. The printing is accomplished by plungers within the housing which strike a ribbon **24** that lies in front of the card. The ribbon moves between rollers **13** and 15 mounted on the housing. The plungers are held in a plunger plate 22 of the housing, and are moved by solenoids held in a front solenoid plate 18 and rear solenoid plate 20 of the housing.

FIGURE 2 illustrates a portion of the printing apparatus of FIGURE 1, showing several of the mechanisms, each of which can print one dot on the card. The printing apparatus comprises the front solenoid plate 18, the rear solenoid plate 20, and the plunger plate 22, which is located between the two solenoid plates. Each of the three plates has 100 holes arranged in ten columns and ten rows, and corresponding holes in the three plates are aligned with each other. The card receiving slot 12 lies between the front solenoid plate 18 and the plunger plate 22. A portion of the ribbon 24 is positioned in the slot adjacent to the plunger plate 22 and is held taut by the ribbon rollers. The space between the ribbon 24 and solenoid plate 18 is adapted to receive a card 14 on which information is to be printed.

A dot is printed on the card 14 when a plunger 46 strikes the ribbon 24, moving it against the card 14. Each plunger is essentially a permanent bar magnet with a front or marking end 50 of one magnetic polarity and a rear end 48 of the other magnetic polarity. The plunger 46 is propelled toward and away from the card by a pair of solenoids. A front solenoid 26 is positioned near and in opposed relation to the marking end 50 of the plunger, while a rear solenoid 36 is positioned adjacent to and in opposed relation to the rear end 48 of the plunger. When the solenoids are energized with currents in one direction, they both move the plunger toward the card, the front solenoid 26 pulling it by magnetic attraction and the rear solenoid 36 pushing it by magnetic repulsion. Reversal of currents in the solenoids moves the plunger away from the card. A detailed description of the apparatus will be given below.

A separate front solenoid 26 is positioned in each hole of the front solenoid plate 18. Each front solenoid comprises a core 28 constructed of a narrow rod portion 30 and a wide face portion 32. The face portion 32 faces the slot 12, while the narrow rod portion 30 extends along the length of the hole. A solenoid winding 34, comprising multiple turns of an electrical conductor, is disposed about the rod portion 30. The rear solenoid plate 20, located at the rear end of the plungers, is similarly constructed, with a rear solenoid 36 in each of its holes. Each rear solenoid similarly comprises a core 38 with a rod portion 40 extending along its length and a face portion 42 facing the plunger plate 22. A rear solenoid winding 44 is wound about the rod portion 40.

A plunger 46 is disposed in each hole of the plunger plate 22. Each plunger is a cylindrical rod constructed of permanent magnet material, such as Alnico, and functions like a bar magnet. The rear end 48 of each plunger is positioned adjacent to the face portion of a rear solenoid, while the front or marking end 50 is positioned adjacent to the ribbon 24. The marking end 50 is tapered to an almost flat tip, which contacts a small round area of the ribbon. The solenoid 36 has a length approximately equal to the width W of the plunger plate 22 within which it moves, so it travels a small distance before contacting the ribbon. The magnetic polarities of the plunger ends are indicated by the N and S signs designating the north and south poles, respectively.

Each of the two hundred solenoid windings has two terminals, a first of which may be grounded, as by connection to a common grounding wire. The second terminal, such as terminal 54 of the solenoid 26, is connected to the second terminal 58 of the rear solenoid 36 with which it is aligned. Both terminals are connected to a contact 62 of a selecting switch 64. The other contact of the switch is connected to a common conductor 66 which carries currents from a common switch 80 to energize the solenoids. If any of the selecting switches, such as switch 64, is in a closed position at a time when there is a voltage on the conductor 66, both the front and rear solenoids which are aligned with one of the plungers are energized.

The front and rear solenoid windings of each plunger are connected so that, when they are energized, their core face portions 32 and 42 have the same magnetic polarity. Both of the solenoids will tend to move the plunger 32 in one direction. The plunger will move toward the front solenoid or toward the rear solenoid, depending upon the direction of current from the common conductor 66. For example, if the current at any instant is in a direction which makes the face portions 32 and 42 of the solenoids magnetically north, then the plunger 46 will move toward the front solenoid. This occurs partly because the marking end 50 of plunger 46 is magnetically south and is attracted by the north pole of the core face portion 32. Additionally, the rear end 48 of the plunger is a north pole and is repelled by the north pole at the face of the rear solenoid 36.

The combined pulling and pushing action of the front and rear solenoids moves the plunger with considerable force to provide clear markings. A large force is obtained because a small permanent magnet plunger of high field strength can be obtained by using Alnico or other good permanent magnet material. Magnetic attraction is generally proportional to the product of the field strength of interacting magnetic poles, so high forces are produced with only moderate strength solenoids.

FIGURE 4 illustrates the plunger plate 22 and the matrix of one hundred plungers therein. The figure also shows the slots 72 and 74 through which the ribbon moves. As shown in the figure, the plungers are arranged so that the marking end of adjacent plungers are of opposite polarity. For example, the plunger 46 has a marking end of south polarity, and the plungers on either side of it in the same column or same row have north polarities. The arrangement of north and south pole marking ends interspersed with each other has been found to be generally necessary to prevent adjacent plungers from moving when the pair of solenoids of only one of them has been activated. It might be supposed that all solenoids should be arranged with their marking ends of the same polarity. However, it has been found that the plungers move together when such an arrangement is used. As a byproduct of the arrangement of adjacent plungers with opposite polarities, the plungers do not readily lose magnetic strength because lines of magnetic force from a pole of one plunger have a short path before entering an opposite pole.

The illustrated card printer is used by an operator who causes ten out of the one hundred selecting switches of the type shown at 64 in FIGURE 2 to be closed. One selecting switch is closed as each digit of a 10 digit number is dialed. When all ten digits have been dialed, and the call has been completed, the operator inserts a card into the slot of the card printer and closes a switch 76 shown in FIGURE 2. Closing of the switch 76 activates a relay control apparatus 78. The relay control apparatus 78 controls a relay 79 to operate the common switch 80. The switch 80 is thrown from a neutral position into contact with positive terminal 82, then into contact with negative terminal 84, and then back to a neutral position. The positive terminal 82 is connected to a positive voltage source, while the negative terminal 84 is connected to a negative voltage source, as by connecting a battery between them.

When the switch 80 contacts the terminals 82 and 84, currents flow through the ten pairs of solenoids whose selecting switches have been closed. At the time that the switch 80 contacts positive terminal 82, currents flow through the ten pairs of solenoids in directions which move their plungers toward the card, thereby marking the card. When the switch contacts negative terminal 84, the currents flow in the opposite direction and the ten plungers move away from the card to their rearward position. While a single thrust makes a relatively dark mark, marking clarity is increased if each plunger strikes the ribbon several times for each mark. This is accomplished by providing a relay apparatus **78** which operates the relay **79** to alternate the switch **80** several times between the positive and negative terminals **82** and **84**. The switch **80** should always contact the negative terminal **84** before finally moving to a neutral position. This assures that the plungers will end in a rearward position. The plungers maintain this position when current is thereafter removed, by reason of magnetic attraction with the soft iron face of the rear solenoid. A weak spring return could be used to move the plunger back, instead of reversing the solenoid currents, but the cost of providing circuits to reverse the currents is generally lower than the cost of one hundred additional springs and the provisions required to hold them in place.

The relay apparatus **78** can be constructed in a number of ways well known in the art. For example, it can include pulse generating circuitry to generate a pulse having well defined leading and trailing edges each time the switch **76** is closed. The leading edge can be used to move the switch **80** to the positive terminal **82** while the trailing edge can be used to move the switch to the negative terminal **84**. To move the plungers back and forth several times, a ringing circuit or the like can be provided to generate several spaced signals to operate the pulse generating circuitry each time the switch **76** is closed. The selecting switches, such as switch **64**, should be opened prior to the dialing of the next telephone number to be called, whether or not a card has been printed. This can be done by using a relay for closing each selecting switch, and causing all relays to open their switches when a call is completed. Such apparatus is not part of the invention and therefore has not been shown.

FIGURE 5 is a detailed view of a circuit for providing currents that operate the solenoids and move the printing plungers against a card. The circuit has an output **100** for connection to the common conductor **66** shown in FIGURE 2, in place of the circuitry described above. Unlike the circuit described above, the circuit of FIGURE 5 provides a direct current with a waveform shown at **101**, which varies rapidly in intensity instead of varying rapidly in polarity. As a result, the plungers do not rapidly move back and forth many times but instead move against the card and are alternately hammered hard against the card and partially released. Thereafter, the polarity of the energizing current is reversed and the plungers are returned to their rearward position. It should be understood that the circuit of FIGURE 5 is shown with specific component values only as an example, and many other circuits may be used instead.

The circuit of FIGURE 5 comprises an input switch **76′** which is closed when all 10 digits have been key pulsed or dialed and the operator inserts a card into the slot of the card printer. Closing of the switch **76′** causes a trigger circuit **102** to deliver a positive going pulse to transistor Q_1, thereby turning it on. Transistor Q_1 passes a pulse to transistor Q_2, thereby charging capacitor C_1. The capacitor C_1 thereupon turns off transistor Q_3 for a period such as 350 milliseconds. The current at junction **104** thereupon rises toward 12 volts and remains at this level for 350 milliseconds. The pulse at junction **104** is amplified by the transistors Q_4 and Q_5 and transmitted to relay coil **106**, to close the relay contacts **108** for a period of 350 milliseconds. This allows an output at **100** to be delivered for a period of 350 milliseconds.

During the 350 millisecond interval when junction **104** is at a high level, capacitor C_2 is charged. It requires approximately 175 milliseconds before the junction **110** rises to a value wherein transistor Q_6 is turned on. When Q_6 is turned on, transistor Q_8 completes a circuit in series with a relay coil **112** and a voltage supply at **115**. When current flows through relay coil **112**, relay contact **114** is moved from a contact **116** to a contact **118**. During the first 175 milliseconds before relay coil **112** is energized, currents flow from ground G to terminal **116**, through relay contact **114**, through a transformer coil **120**, and through the closed relay contact **108** to the output **100**. During the second 175 milliseconds, currents flow from a source **122** to terminal **118**, through contact **114** to the output **100**. Thus, during the first 175 milliseconds, a DC voltage with an average value of ground potential G is provided at output **100** while, during the second 175 milliseconds, a voltage with an average value L of that at the junction **124** is provided at the output **100**.

An alternating current is impressed on the direct currents at the output **100**. This is achieved by connecting an alternating current, such as a normal house current of approximately 117 volts to an input of a transformer **126**. This voltage is reduced to a smaller AC voltage across the output coil **120** of the transformer. For a circuit with component values shown in FIGURE 5, the potential L at junction **124** is 40 volts initially, while a reference voltage V_R of 20 volts is provided at junction **128**. For a transformer **126** providing a 6.3 volts root mean square output across coil **120**, the output at **100** during the first 175 milliseconds initially rises to 30 volts above the voltage V_R at the reference junction **128**. During the second 175 milliseconds, the output initially falls to 30 volts below V_R. At the end of the 350 milliseconds interval, the voltage output at **100** is equal to the reference voltage V_R. The reference voltage V_R is connected to the second input of each of the 200 solenoids instead of grounding them.

The apparatus of the invention can be used to print alphanumeric or other characters in addition to the dot characters by using appropriate type faces on the plungers, and by using a track to prevent plunger rotation. Special papers which are marked by striking them can be used to record marks without a ribbon. If thin cards and high currents are used, it is even possible to mark the cards by punching holes in them.

What is claimed is:

1. Printing apparatus for printing material received in a predetermined area comprising:
- an elongated permanent magnet having first and second ends which are substantially magnetic poles;
- means supporting said permanent magnet for reciprocation in substantially linear motion in the direction of its elongation toward and away from said area; and
- a solenoid positioned in opposed relation to said first end of said permanent magnet to move it in the direction of its elongation.

2. Printing apparatus as defined in claim **1** including:
- a second solenoid positioned in opposed relation to said second end of said permanent magnet; and
- means for simultaneously energizing said solenoids to cause each solenoid to impel said permanent magnet in the same direction.

3. Printing apparatus as defined in claim **1** wherein:
- one of said ends of said permanent magnet which is closest to said area in which material is received has a face defining a character to be printed on said material.

4. Printing apparatus as defined in claim **1** including:
- means coupled to said solenoid for providing a direct current which varies in intensity, to vary the force of said magnet against material in said area.

5. Apparatus for marking material comprising:
- means defining an area for receiving material to be marked;
- a plunger including a front end for movement toward said area to mark said material, said plunger constructed of a permanent magnet material and magnetized;
- guiding means for guiding said front end of said plunger in movement toward and away from said area;
- solenoid means positioned adjacent to said plunger for magnetically interacting with it to move said front end thereof toward said area; and

energizing means coupled to said solenoid means for energizing it.

6. Apparatus as defined in claim **5** wherein:

said plunger has a rear end opposite said front end, and is magnetized with said front and rear ends forming magnetic poles; and

said solenoid means comprises a first solenoid having a solenoid face facing said rear end of said plunger and a second solenoid having a solenoid face positioned on a side of said area opposite said plunger and facing said front end of said plunger, to interact with the poles at both ends of said plunger.

7. Apparatus as defined in claim **6** wherein:

said front and rear ends of said plunger have opposite magnetic polarity; and

said energizing means includes means for simultaneously energizing said first and second solenoids to magnetize said faces of said solenoids with the same polarity, thereby to simultaneously push and pull said plunger toward said area.

8. Apparatus as defined in claim **5** wherein:

said plunger is elongated, with a rear end located opposite said front end, and said front and rear end forming magnetic poles; and

said solenoid means is positioned opposite at least one end of said plunger for magnetically interacting with it; and including

a plurality of additional plungers constructed of permanent magnet material and having front and rear-ends which are magnetic poles, said additional plungers positioned laterally from each other for movement toward and away from said area;

a plurality of additional guiding means, each engaged with one of said plurality of additional plungers for constraining it to movement toward and away from said area;

a plurality of additional solenoid means, each positioned opposite an end of each of said additional plungers for magnetically interacting therewith; and

a plurality of additional means for energizing said plurality of additional solenoid means independently of each other for independently moving each of said plungers toward said area.

9. Apparatus as defined in claim **8** wherein:

each a plurality of said plungers with a front end of south magnetic polarity is adjacent to a plurality of other plungers having a front end of north magnetic polarity, whereby to assure movement of only the plungers whose solenoid means are energized.

10. In apparatus including a housing for receiving a card in a card area to mark the card by thrusting a plunger toward the card and against an inked ribbon or other means which causes marking of the card when struck by the plunger, the improvement comprising:

a plunger rod having a marking end facing said card and a rear end, said rod constructed of a permanent magnet material and magnetized with its marking end and rear end of opposite magnetic polarities;

means disposed on said housing for constraining said rod to movement substantially toward and away from said card area;

first solenoid means positioned on a side of said card area opposite said marking end of said rod for magnetically interacting with said rod to pull it toward said card area and push it away therefrom;

second solenoid means positioned adjacent to said rear end of said rod for magnetically interacting with said rod to push it toward said card area and pull it away therefrom; and

means for energizing said first and second solenoid means to impart the same magnetic polarity at substantially the same time to the ends thereof facing said rod to simultaneously push and pull said rod.

11. The improvement in apparatus as defined in claim **10** wherein:

said means for energizing comprises means for delivering a current which reverses direction and is in a direction to move said rod away from said card area immediately prior to substantial termination of current.

12. The improvement in apparatus as defined in claim **10** including:

a multiplicity of additional plunger rods laterally spaced from each other; and

a multiplicity of pairs of solenoids disposed at opposite ends of each of said multiplicity of plunger rods for moving them toward and away from said card area.

13. The improvement in apparatus as defined in claim **12** wherein:

said multiplicity of plunger rods are arranged substantially in rows and columns, and the marking end of each plunger rod has a polarity which is opposite to the polarity of the marking ends of adjacent plunger rods in the same row and of adjacent plunger rods in the same column.

14. A card printer comprising:

a housing having a slot for receiving a card to make markings thereon, plunger plate means for holding a plurality of plungers to mark said card, front solenoid plate means positioned on a side of said slot opposite said plunger plate means for holding a plurality of front solenoids, and rear solenoid plate means positioned on a side of said solenoid plate means opposite said slot for holding rear solenoids;

a plurality of permanent magnet plungers disposed in said plunger plate means for movement toward and away from said slot, each plunger having a marking end for marking a card when the plunger is moved toward said slot;

a plurality of front solenoids disposed in said front solenoid plate means, each aligned with one of said plungers;

a plurality of rear solenoids disposed in said rear solenoid plate means, each aligned with one of said plungers; and

means coupled to said solenoids for substantially simultaneously energizing a front solenoid and a rear solenoid which are aligned with one of said plungers, with currents in directions which energize one solenoid to pull said plunger while the other pulls it by magnetic interaction.

15. A card printer as defined in claim **14** wherein:

a first plurality of said plungers has marking ends of north magnetic polarity and a second plurality of said plungers interspersed with said first plurality of plungers has marking ends of south magnetic polarity.

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RICHARD B. WILKINSON, *Primary Examiner.*

JOSEPH W. HARTARY, *Assistant Examiner.*

U.S. Cl. X.R.

101—93; 179—7.1; 197—53; 234—108; 335—229; 346—141