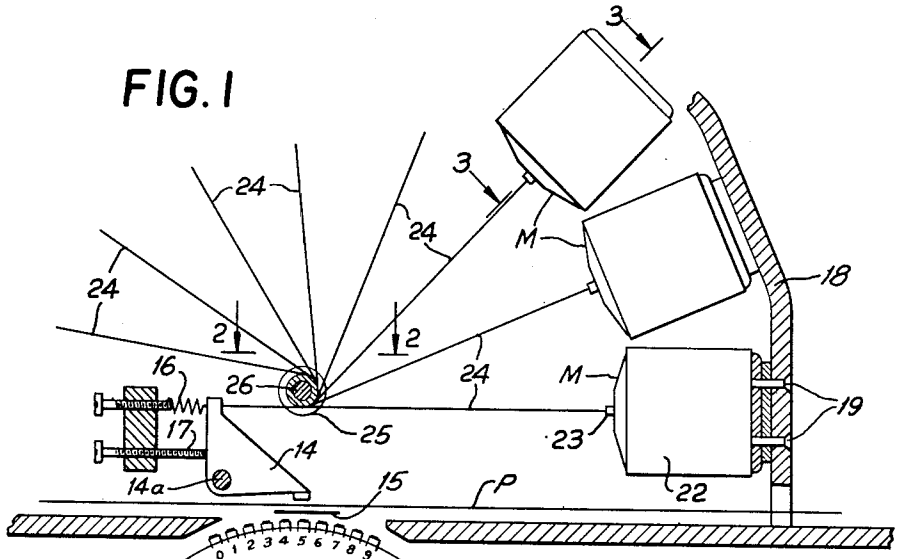
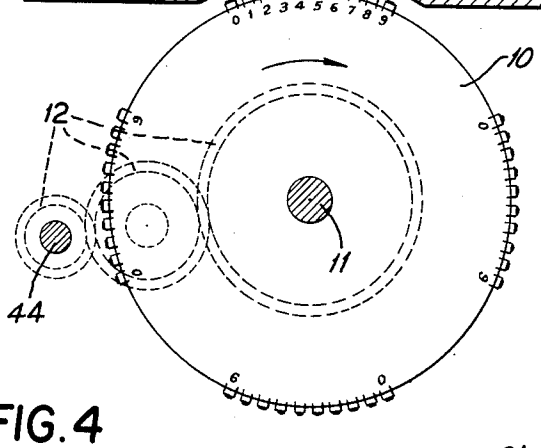
Aug. 17, 1954 O. L. GORE ET AL 2,686,470

HAMMER IMPELLING MEANS FOR HIGH-SPEED PRINTERS

Filed April 16, 1952 3 Sheets-Sheet 1

FIG. 1





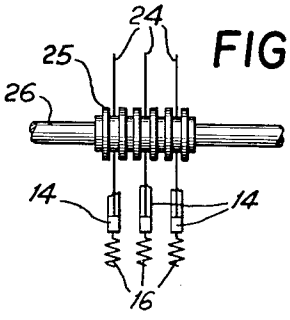


FIG. 2

FIG. 4

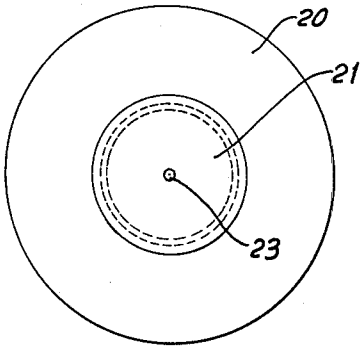
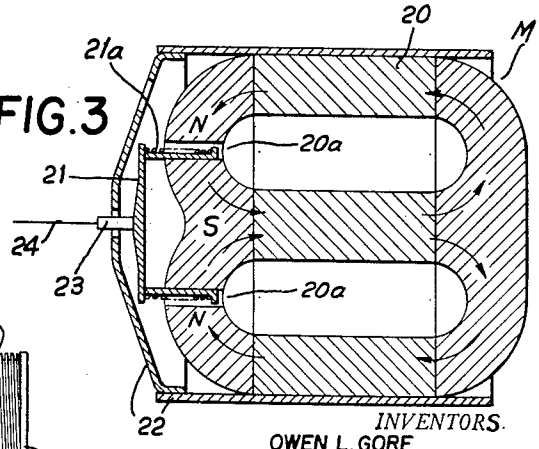


FIG. 3



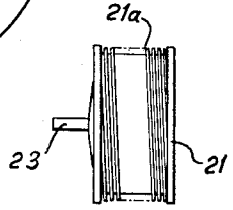


FIG. 5

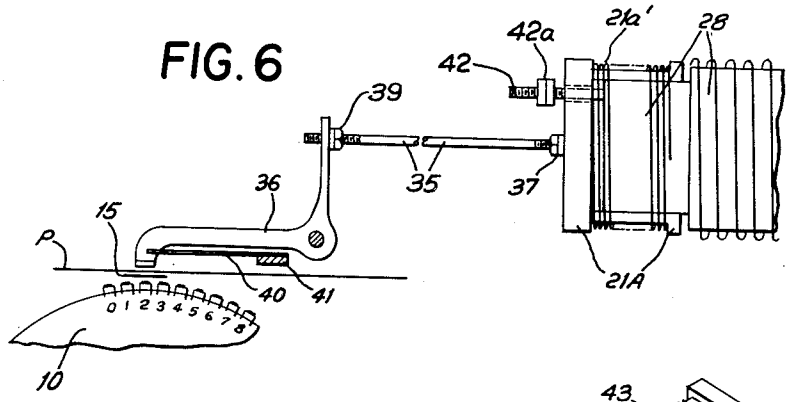
INVENTORS.
OWEN L. GORE
PERRY CRAWFORD, JR.
THEODORE C. GAMS
BY
Joseph J. Robbins
ATTORNEY

Aug. 17, 1954 O. L. GORE ET AL 2,686,470

HAMMER IMPELLING MEANS FOR HIGH-SPEED PRINTERS

Filed April 16, 1952 3 Sheets-Sheet 2

FIG. 6



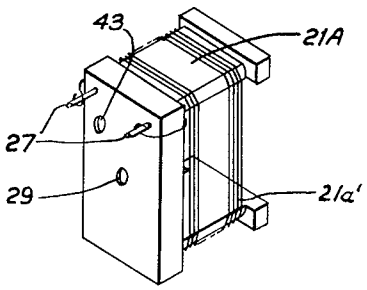


FIG. 7

FIG. 8

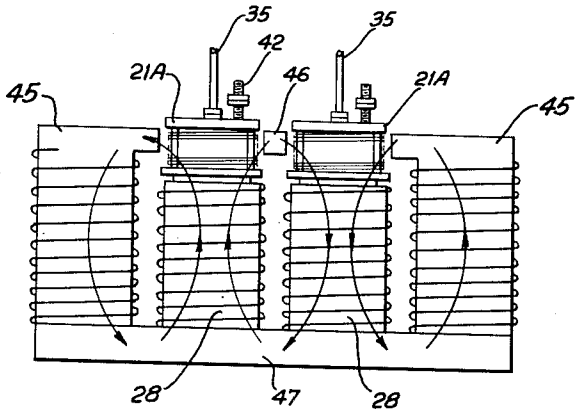


FIG. 9

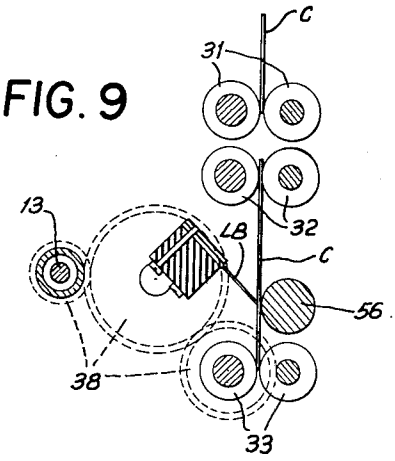
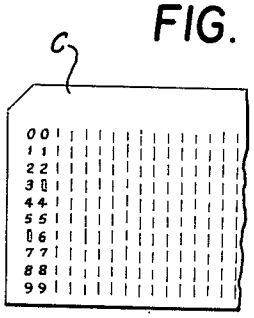


FIG. 10



INVENTORS.
OWEN L. GORE
PERRY CRAWFORD, JR.
THEODORE C. GAMS
BY Joseph J. Robbins
ATTORNEY

Aug. 17, 1954 O. L. GORE ET AL 2,686,470

HAMMER IMPELLING MEANS FOR HIGH-SPEED PRINTERS

Filed April 16, 1952 3 Sheets-Sheet 3

FIG. 11

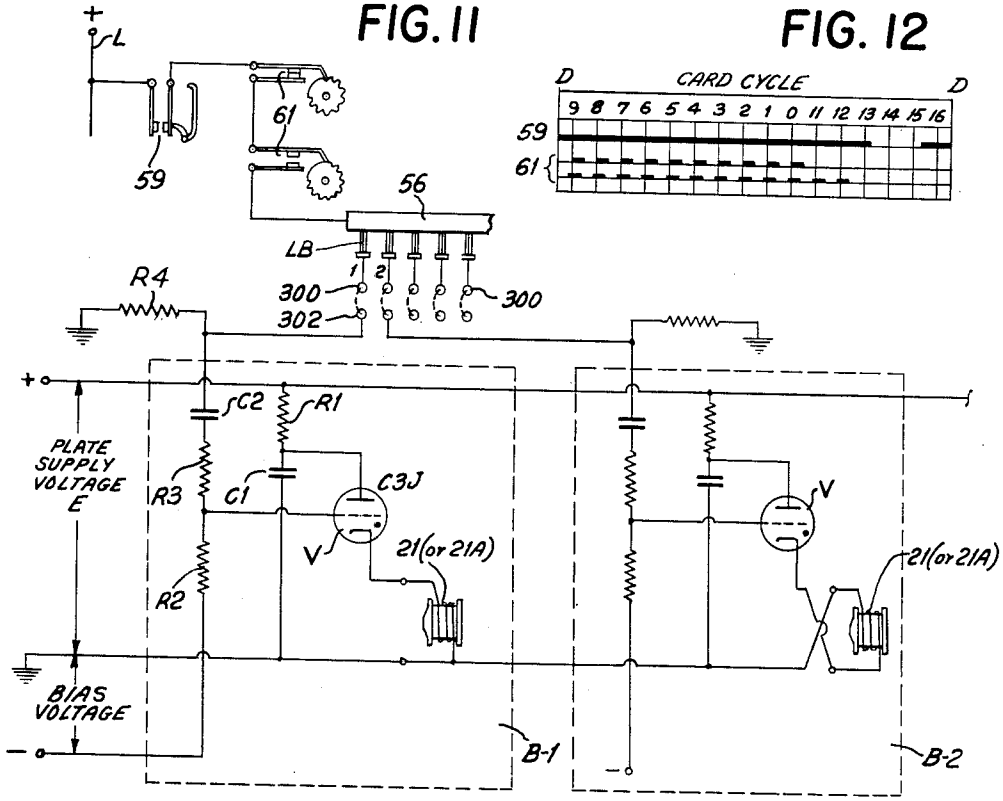
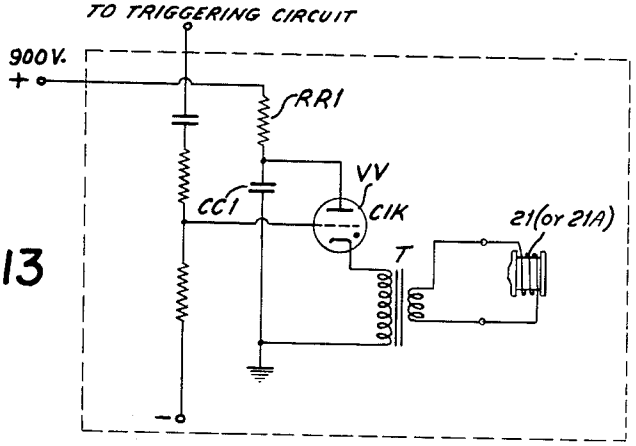


FIG. 12

FIG. 13



INVENTORS.
OWEN L. GORE
PERRY CRAWFORD, JR.
THEODORE C. GAMS
BY Joseph J. Robbins
ATTORNEY

Patented Aug. 17, 1954

2,686,470

UNITED STATES PATENT OFFICE

2,686,470

HAMMER IMPELLING MEANS FOR HIGH-SPEED PRINTERS

Owen L. Gore, Manhasset, Perry Crawford, Jr., Great Neck, and Theodore C. Gams, Monsey, N. Y., assignors to The De Florez Company, Inc., New York, N. Y., a corporation of Delaware

Application April 16, 1952, Serial No. 282,626

2 Claims. (Cl. 101—93)

1

This invention relates to printing apparatus, particularly to its imprinting means, and more particularly to imprinting means for effecting printing operation in response to electrical print-call signals.

The general object of the invention is to provide novel imprinting means capable of extremely high speed of operation under electrical impetus.

More specifically, an object of the invention is to provide an imprinting device with magnetic impelling means involving a movable coil energized in response to a print-call signal for interacting with a fixed magnetic field to develop self-impelling force imparted by the coil to a print-effecting structure.

Still more specifically, an object of the invention is to provide imprinting means with a magnetic impelling unit involving a fixed magnet and a proximate movable coil within a fixed magnetic field established by the magnet. According to the invention, a pulse of current will be sent through the coil in response to an electrical, character-selecting print-call signal and will thread the coil with a magnetic flux, the interaction of which with said magnetic field will develop accelerating force on the coil, whereupon the coil will impart this force to an imprint-effecting device to impel it through a printing stroke. The force thus developed is proportional to the product of the intensity of the fixed magnetic field and the current sent through the movable coil and is independent of the mass of the coil. A very large force may be developed, within the limitation of the amount of current which the coil may carry without overheating.

According to the invention, the mass of the movable coil and the mass of the impression-effecting structure driven thereby may be extremely low relative to the large force induced upon the energization of the coil. The high ratio of force to mass will result in large acceleration of the assembly of coil and impression-effecting structure. Further, the assembly may perform an extremely short stroke and yet, because of the large acceleration, attain sufficient impact energy to produce a sharp, clear imprint. The large acceleration and the short stroke of the assembly combine to define a printing time of exceedingly small duration, which can be in the order of a fraction of a millisecond.

The novel imprinting device is particularly adaptable to a printing apparatus in which selected types on continuously moving carriers are struck by type hammers while the types are in motion. Operation of the hammers is controlled

2

by signals timed according to the data to be printed. Such timed signals may be derived, for instance, from the sensing of codally designated data on record material.

According to the invention, the timed signals will initiate excitation of the movable coils of the novel magnetic, impelling units to impel the associated type hammers for striking types, selected by the signals, while the types are in motion. The great rapidity of action of which the novel imprinting means is capable enables the type carriers to be moved at far greater speed than formerly practicable. In view of the high speed of the type carriers and the exceedingly short printing time of the imprinting means, it is important that the imprinting means reliably respond to the timing signal in a very small fraction of the printing time. Slight variations in response of the imprinting means to the control signals may otherwise result in printing characters incompletely or out of line. Accordingly, an object of the invention is to provide electronic circuitry for effecting substantially instant response of the imprinting means to the control signals or, more specifically, for effecting substantially instantaneous excitation of the movable coils of the magnetic impelling units in response to timed print-call signals.

It is contemplated that the fixed magnet of the impelling unit for the impression-effecting structure may be either a permanent magnet or an electromagnet and that the movable coil may be either rockably or linearly movable. Preferably, the coil will be linearly movable and the induced impelling force, the coil movement, and the acceleration of the imprinting link actuated by the coil will all be in the same direction so that the impelling force will be applied with maximum effect.

Other objects and advantages will become clear from the detailed description, the claims, and the drawings.

As illustrative, the invention will be explained in connection with a printing apparatus controlled by a record handling machine such as disclosed in Patent No. 1,976,617 to C. D. Lake et al., but it will be understood that the invention is applicable to any printing apparatus in which printing is to take place under control of electrical signals.

In the drawings:

Fig. 1 is a sectional view through printing apparatus incorporating the novel imprinting means.

Fig. 2 is a plan view of certain elements of this

printing apparatus, substantially as indicated by line 2—2 of Fig. 1.

Fig. 3 is a section along line 3—3 of Fig. 1 and shows, on an enlarged scale, the form of magnetic, hammer impelling unit in which a permanent magnet is associated with the movable coil.

Fig. 4 is a front view of the Fig. 3 unit, with the cover removed.

Fig. 5 is a side view of the coil of the Fig. 3 unit.

Fig. 6 is a side view of a printing assembly using a hammer impelling unit of an alternative form in which the fixed magnet associated with the movable coil is an electromagnet.

Fig. 7 is an isometric view of the movable coil of the latter unit.

Fig. 8 is a plan view of a magnetic structure constituting a spaced pair of hammer impelling units of the form provided with electromagnets to coact with the movable coils.

Fig. 9 is a section through record card feeding and sensing elements of an illustrative record handling machine which may be used to control the printing apparatus.

Fig. 10 shows a fragment of a record card.

Fig. 11 is a circuit diagram showing a pair of coil exciting circuits in connection with the record card sensing circuit of the record handling machine.

Fig. 12 is a timing chart of circuit breakers and a card lever contact present in the record card sensing circuit.

Fig. 13 shows an alternative coil exciting circuit.

Referring to Fig. 1, typical printing apparatus with which the invention may be used includes a type wheel 10 bearing similar sets of types for printing characters 0 to 9. This type wheel and others like it are fixed side-by-side, in the usual manner, to a shaft 11. Shaft 11 is rotated through gearing 12 by a shaft 44. Above the type wheels are type hammers 14 (also see Fig. 2) individually rockable about a common rod 14a. Between the hammers and the type wheels are an imprint receiving paper web P and an ink ribbon 15. The paper may be fed by any conventional means as, for example, the line spacing means in Patent No. 1,976,617. Springs 16 normally retract the hammers 14 against adjustable stops 17.

The invention provides novel magnetic, hammer impelling units M, each secured, with the capability of slight positional adjustment, to a frame 18 by means of threaded elements 19. Each unit M includes a permanent magnet 20 and a movable coil 21 (see Figs. 3, 4, and 5). The permanent magnet, in the illustrative form, is a composite structure of pole pieces, is generally cylindrical in shape, and has a lobe-shaped front end formed with a narrow, circular magnetic gap 20a. The flux of the magnet 20 is in the indicated directions and establishes a strong magnetic field radially across the circular gap 20a. The movable coil comprises a bobbin of very light material (thin nylon has been found satisfactory) on which the coil wire 21a is wound. The bobbin has a free slidable fit on the inner circle of the gap 20a and can move axially inward until it abuts the front of magnet 20. A two-part cover 22 is provided for magnet 20, the front plate of the cover limiting outward displacement of coil 21. Extending axially forward from the coil head and passing with clearance through an opening in the front plate of cover 22 is a thin tubular rod 23. A pull wire 24 is fastened at one end into the rod 23 and secured at the other end to a type hammer 14, engaging between its ends with a guide sheave 25. A plurality of such sheaves 25 are rotatably carried by a fixed shaft 26 and guide the pull wires 24 from the different magnetic units M into the same direction and leverage of pull on the associated type hammers 14.

Attention is called to the fact that the axis of a coil 21 is perpendicular to the radial direction of the magnetic field across the gap 20a. Hence, when current is passed through the coil winding, it sets up a magnetic flux which interacts with the magnetic field across gap 20a to propel the coil axially. The direction of current flow through the coil will decide whether the coil will be propelled axially inward toward the magnet 20 or axially outward, away from the magnet. In the form of printing assembly shown in Figs. 1 to 5, current will be sent through the coil in a direction to cause axially inward movement of the coil. Upon such movement of the coil, it pulls on the connected wire 24 to impel a hammer 14 clockwise for effecting a printing stroke.

The entire coil assembly is extremely light, while the current pulse which can be sent through the coil winding is very large. Thus, the ratio of inducible energy to the mass of the coil is very high, the limitation to the amount of energy developed being only a function of the amount of current the coil winding can carry without excessive heating due to its resistance.

The expression for the force generated on the coil at the beginning of current flow is:

$$Fo=\frac{B\times Io\times Lc}{10}$$

where B is the flux density at the coil due to the fixed magnet, Io the current through the coil, and Lc the effective length of the coil winding.

As indicated by the above expression, the force developed on the coil is proportional to the product of the fixed magnet field intensity and the current sent through the coil. Since the current threads the coil with a magnetic flux in air, which has no finite magnetic saturation limit, it is evident that the force developed on the coil could be increased without limit by proportionately increasing the current. In practice, however, care must be taken not to overheat the coil and this acts as the practical limitation to the maximum amount of current which may be sent through the coil. Although the force developed on the coil can be extremely high, the coil itself can be extremely light since it may be comprised of a very light bobbin and a comparatively small number of turns of conductive wire.

In view of the very high ratio of force which can be developed on the coil to the mass of the coil, its acceleration can be very large. The entire actuable impression-effecting assembly, including the movable coil, the type hammer, and the connection between them will preferably be made of such light weight in comparison to the large magnitude of force induced upon the energization of the coil, that a very large acceleration will be imparted to the assembly. It follows that the actuable impression-effecting assembly may perform an extremely short stroke and the type hammer will nevertheless strike a type with sufficient impact energy to produce a sharp and clear imprint on an imprint-receiving medium. As a corollary to the large acceleration and short stroke of the impression-effecting assembly, its printing time will be of an exceedingly short duration.

As an example, by no means to be taken as a limiting case, the imprinting device may be provided with a coil **21** of which the winding **21***a* may, for instance, have an effective length, Lc, of 1,000 cm. (represented by, for example, 76 turns); the fixed magnet **20** may provide a field density, B, of, say, 4,000 gauss; and the current Io sent through the coil may be, for instance, 30 amps. The force, Fo, developed on the coil will then be 12,000,000 dynes, equal to 5.35 lbs. The coil assembly in this example may weigh no more than about 15 gms.; i. e., about ½ ounce, and be given an acceleration by the developed force of about 250 g's. The coil may, in a stroke of no more than about .012 in., for example, effectively impart its acceleration to the actuable imprinting means to cause this means to make a sharp, clear imprint on the medium (P). In practice, a printing time of a fraction of a millisecond has been attained with such imprinting device.

The great speed with which the novel imprinting device can act allows the type wheels to be rotated continuously at far higher speed than formerly possible. Nevertheless, printing time is of such brief duration that at the moment of hammer impact on a type, the type may be considered as being relatively at rest.

The transverse spacing between adjacent magnetic units M is greater than the spacing between adjacent type hammers **14**. Accordingly, the units M are arranged in staggered fashion around the hammers, being offset in transverse direction, with one unit overlapping the position of the next in said direction. Three such units are shown in Fig. 1 and the presence and positions of others in a series are indicated by their associated pull wires **24**. One or more of such series of units M may be provided, depending on the number of type hammers to be operated.

Figs. 6 to 8 show an alternative imprinting assembly using a magnetic, hammer impelling unit with an electromagnet in coaction with a movable coil, here designated **21**A. For extreme lightness of weight, the coil bobbin is U-shaped. The ends of the coil winding **21***a'* may be brought to terminal pins **27**. A core piece **28** of the electromagnet has a reduced, rectangular front end on which the coil **21**A is mounted for linear slidable movement. While the coil may be connected to a type hammer by a tie rod or a wire, the advantages of a snap printing action may be obtained by the push connection shown in Fig. 6. The push connection includes a link **35** one end of which freely extends into a hole **29** in the coil head (see Fig. 7) while the other end loosely passes through a hole in the vertical arm of a type hammer **36**. The link is threaded near its ends to carry nuts **37** and **39** for limiting longitudinal play of the link between the coil head and the type hammer. A leaf spring **40** normally holds the hammer in retracted position, above the paper P, ink ribbon **15**, and type wheel **10**.

In this form of the invention, the movable coil **21**A will be impelled outwardly. Upon such movement of the coil, it will impart its motion positively to link **35** and hammer **36** until stopped by a nut **42***a* on a stud **42** extending from core piece **28** and passing freely through a hole **43** in the coil head. The coil is stopped before the hammer completes its printing stroke, but the momentum of the hammer carries it through to completion of the printing stroke. Since the hammer is unrestrained by its impelling means at the moment of printing impact, it is able to rebound rapidly, the effect being that the hammer strikes a type with a snap blow. With the type carrier travelling at very high speed during printing operation, as in the case here, the rapid rebound of the hammer has the advantage of providing for minimum time of hammer and type contact, insuring absence of blurred or smudged impressions. Further, with the relatively delicate coil **21**A released from the hammer during printing impact, the coil receives none of the shock of the impact.

Fig. 8 shows a form of electromagnetic structure which provides a uniform transverse field for two coils **21**A. Besides core pieces **28**, this structure includes a pair of core pieces **45**, a cross piece **46**, and a yoke **47**. Current from a suitable D. C. source will be supplied the windings on the core pieces to induce flux in the indicated directions. This flux establishes a transverse field for each of the pair of coils **21**A so that when a current pulse is sent through a coil, it will be impelled in an axial direction to operate a type hammer. The coils of the magnetic structure are spaced several times the spacing between adjacent hammers **36**. Accordingly, to enable adjacent hammers to be operated, a plurality of the magnetic structures such as in Fig. 8 will be arranged in staggered formation about the hammers, in a manner such as indicated for units M in Fig. 1, to permit a coil on one of these structures to operate one hammer, a coil on a next such structure to operate the next hammer, and so on.

The movable coils of the magnetic, hammer impelling units may be energized under control of print-call signals from any suitable source. As illustrative, the control of the coils by signals derived from the sensing of cards in a card handling machine of the kind disclosed in Patent No. 1,976,617 will be explained. Fig. 10 shows a portion of the controlling card C. The card has columns of index positions 0 to 9, and a perforation in an index position of a column designates the digit denoted by the number of the position; e. g., columns 1 and 2 are perforated to designate "63." Fig. 9 shows card feeding and sensing means of said card handling machine. The cards are fed, a distance apart, by pairs of feed rolls **31**, **32**, and **33** and are sensed, while in motion, by coaction of a common contact roll **56** with brushes LB, one for each card column. The cards are fed bottom first so that index positions 9 to 0 are sensed in sequence. Feed rolls **33** are driven through a gear train **38** from a clutchable card cycle shaft **13** which also drives the other feed rolls through gearing not shown. In order to provide for synchronism between the card handling machine and the printing apparatus, the card cycle shaft **13** will be geared to the shaft **44** which drives the type wheels **10** (see Fig. 1). The shaft **44** may, for instance, correspond to the same-numbered shaft in Fig. 3 of the aforementioned patent. In the illustrative printing apparatus, the type wheels will be rotated through one revolution for four revolutions of the card cycle shaft. For this reason, the type wheel **10** has four sets of types. The arrangement is such that types 9 to 0 of a set will move across printing position in step with the sensing of index positions 9 to 0 of a record card C.

Fig. 11 shows a form of the electronic circuit B used to supply energy to a movable coil **21** (or **21**A) and also shows the connection of the electronic circuit to the card sensing circuit of the

record handling machine discussed above. Basically, circuit B consists of a thyratron tube V for rapidly discharging a capacitor C1 through a movable coil when a triggering pulse is applied to the tube. The discharge through the coil is essentially in the form of a current pulse decaying exponentially from a high initial value. Before the triggering pulse arrives, tube V is not conducting because its grid is returned to a negative bias through a resistor R2. Capacitor C1 is allowed to charge through a resistor R1 to essentially full plate supply voltage E since the time constant $R1 \cdot C1$ is short compared to the time between successive triggering pulses to the same tube. The triggering pulse is applied through a capacitor C2 and a resistor R3. Capacitor C2 acts as a D. C. block and performs a differentiation on the input pulse to shorten it so as to assure that it will not be present at the time the tube V is to deionize.

In the illustrative circuit system shown in Fig. 11, the triggering pulse for a coil exciting circuit will result from the sensing of perforations in the record cards C (Fig. 10). On the common side of the sensing circuits for all the card columns are a card lever contact 59 and circuit breakers 61, the timing of 59 and 61 being shown in Fig. 12. The brushes LB are wired to plug sockets 300 selectively pluggable to sockets 302. An electronic circuit B may be wired to each plug socket 302. As shown, electronic circuits B–1 and B–2 are wired to the sockets 302–1 and 2 which are plugged to brushes LB–1 and 2 for sensing card columns 1 and 2, respectively.

Assume that brush LB–1 senses a "6" perforation. This occurs during the "6" cycle point of the card cycle (Fig. 12) and a triggering circuit is established as follows: From the positive terminal L of a voltage source, through 59 and 61 (Fig. 11), 56, LB–1, 300–1, plugging to 302–1, thence to C2 of circuit B–1, and via R3 and R2 to the negative terminal of the bias supply. The resulting triggering pulse entirely overcomes the negative bias on the grid of tube V of circuit B–1 and the tube ionizes and begins to conduct. Capacitor C1, which has been charged up before the arrival of the triggering pulse, now discharges through tube V and the coil 21 (or 21A) in series with the tube. The coil becomes energized and, in the manner previously described, impels a type hammer to effect an imprint. It is to be noted that the coil exciting circuit will respond to the triggering pulse, and the energization of the movable coil and its consequent hammer impelling movement will begin, within a very few microseconds of the arrival of the triggering pulse. The total time required to effect the imprinting operation is in the order of a fraction of a millisecond. Hence, the type wheel 10 and the record cards C may be moved at very high speed. In the example where a "6" perforation is sensed, the type hammer will be impelled by the energized coil to strike the type 6 as it moves past printing position.

The exact nature of the current wave form of the energizing current of the movable coil 21 (or 21A) is dependent on the electrical characteristics of the coil winding but is very close to an exponential decay, starting at peak current value substantially as given by the expression:

$$Ip = \frac{E - Ev}{Rc}$$

where Ip is peak current value, E is the plate supply voltage, Ev is the arc-drop voltage of tube V, and Rc is the resistance of the coil winding.

When the discharge current decays below the extinction current value of the tube V, the tube stops conducting and the current pulse through the movable coil ends. The value of R1 is chosen high enough so that capacitor C1 cannot charge up rapidly enough to prevent deionization of the tube.

The presence of inductance in the movable coil has some effect, but by suitable design its effects may be minimized.

When the tube V stops conducting, the bias recovers control, capacitor C1 recharges, and the circuit B reverts to its original condition ready to respond to the next triggering pulse, any charge in capacitor C2 meanwhile leaking off through a resistor R4 to ground.

In Fig. 11, the coil in circuit B–1 is shown as connected between tube V and ground to receive a current pulse in one direction, while the coil in circuit B–2 is shown with its connections reversed to receive current in the opposite direction. Actually, both coils may be connected to receive current in the same direction, the showing in Fig. 11 merely indicating how current direction may be determined, the current direction, in turn, determining whether the coil will move toward or away from the fixed magnet.

In the Fig. 11 circuit, the tube V may be of type C3J, for example, and coil 21 may have a resistance of 10 ohms, for instance. Other suitable values may then be as follows: Positive terminal L at about 60 volts, plate supply at about 350 volts, bias at about −30 volts, R1 about 5,000 ohms, R2 about 100,000 ohms, R3 and R4 each about 10,000 ohms, C1 about 40 mfds. and C2 about .01 mfd. It is to be understood that other suitable values may be used, depending on the resistance of the movable coil, and that any other suitable type of tube may be used, the stated values and tube type being merely representative.

The Fig. 11 circuit has the limitation that the current pulse, although very short, is so large that the tube used must be a large, heavy-duty, expensive type capable of withstanding such large current surges repetitively. Conversely, if a smaller, cheaper tube is used, its life will be relatively short, necessitating frequent replacement.

Fig. 13 shows a coil exciting circuit for eliminating the above difficulty. In Fig. 13, the movable coil 21 (or 21A) is coupled to a thyratron tube VV by a transformer T. Preferably, the transformer has a large step-down ratio. Capacitor CC1 can be smaller than capacitor C1 (Fig. 11) but will be charged to a higher voltage. Tube VV, when triggered, then discharges the smaller capacitor, charged to a higher voltage, through the "reflected" coil resistance, as seen in the primary of the transformer. The resulting secondary current, energizing the coil, can still be high, but the tube is now required to deliver a much lower surge of current than the tube V of the Fig. 11 circuit. The transformer should be designed to maintain the resistive character of the coil impedance.

As an example, the transformer T may have a step-down ratio of 3:1, the movable coil may have a resistance of 10 ohms, capacitor CC1 may have a value of approximately 5 mfds., the tube VV may be of the C1K type, and plate supply voltage may be in the order of 900 volts. The remaining elements of the Fig. 13 circuit can have the same values as the corresponding ele-

ments of the Fig. 11 circuit. These constants and tube type are understood to be merely illustrative and any other suitable constants and tube type may be used to carry out the purpose of the Fig. 13 circuit.

While the invention has been disclosed with reference to certain printing apparatus and print-call means, it is to be understood that the principle of the invention may be applied to other printing apparatus and that the print-call signals may be obtained from other means than shown here. It is further to be understood that variations in the form and details of the illustrated embodiments may be made without departing from the principle of the invention.

What is claimed is:

1. For a printing apparatus provided with a continuously movable series of types; a hammer impelling unit having a fixed magnet and a contiguous movable coil responsive to a flow of electrical energy therethrough for interacting with said magnet to develop self-impelling force, a type hammer thereupon impelled by the coil into printing impact with a selected one of the types in motion, an electrical energy storing circuit triggerable by an input pulse to discharge electrical energy through the coil, and means for applying a timed type selecting input pulse to said circuit, said circuit including a normally

deionized gaseous discharge tube, a transformer coupling the tube and the coil, with the primary of the transformer being in series circuit with the tube, and a capacitor connected in parallel with said series circuit to be charged during deionization of the tube and to discharge through the tube and the transformer primary upon ignition of the tube.

2. The invention as set forth in claim 1, said transformer having a step-down ratio to produce an amplified pulse of current through the coil upon discharge of the capacitor.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
436,319	Silkman	Sept. 9, 1890
718,929	Harrison et al.	Jan. 20, 1903
1,675,969	Bull	July 3, 1928
1,732,644	Farrand	Oct. 22, 1929
2,013,533	Buhler	Sept. 3, 1935
2,030,427	Buhler	Feb. 11, 1936
2,053,063	Bryce	Sept. 1, 1936
2,446,851	Ruderfer	Aug. 10, 1948
2,454,425	Bauer	Nov. 23, 1948
2,556,816	Lukacs	June 12, 1951
2,580,870	Wilkerson	Jan. 1, 1952
2,613,796	Prouty	Oct. 14, 1952