An electric typewriter in which a printed circuit board is arranged under the keys of the keyboard, respective conductive areas of the circuit being associated with the keys and connected conductively to an amplifier through a synchronizing mechanism, the types being moved against a paper wrapped about a cylinder when the associated key is depressed toward the printed circuit.
ELECTRIC TYPEWRITER WITH PRINTED CIRCUIT KEYBOARD

This invention relates to electric typewriters, and particularly to typewriters in which paper or other sheet material is wrapped about a cylinder and impressed by type selected by depressing keys in a keyboard.

Many known electrical typewriters are provided with a multiplicity of levers, pivots, links, and the like which are associated with the keys of the keyboard. The many mechanical elements cooperating with the keys proper are costly and require much labor for assembly.

In other known electrical typewriters, microswitches are respectively associated with the keys of the keyboard and initiate electrical signals when the keys are struck, whereby the writing mechanism proper is suitably actuated. The use of the necessary large number of microswitches not only increases the cost for the material of the typewriter, but requires much labor for assembly, particularly for wiring the switches.

A primary object of the present invention is the provision of an electric typewriter which is free from the afore-described shortcomings of known devices, and whose cost is low because of the use of a keyboard which can be manufactured and installed at low cost. According to the invention, a printed circuit board is arranged under the keys of the keyboard and has conductive areas respectively associated with the keys. The several conductive areas are connected by elongated conductors to an amplifier whose output signal is employed for operating the writing mechanism of the typewriter.

According to a preferred embodiment of the invention, a resilient, electrically conductive foil and a perforated, electrically insulating sheet are interposed between the keys and the printed circuit board in such a manner that the conductive areas of the printed circuit board are engaged by respective portions of the conductive foil which pass through the perforations of the insulating plate when the keys are depressed. If it is preferred to avoid the closing of mechanical contacts and the maintenance problems arising therefrom, an electrically insulating foil and an electrically conductive foil may be interposed between the keyboard and the printed circuit board, the portions of the conductive foil sufficiently approaching the conductive areas of the printed circuit board under a depressed key that the change in the capacitance between the conductive foil and the printed circuit causes a signal to be generated.

The printed circuit board preferably consists of flexible material so that the portion of the board carrying the elongated conductors may be shaped in any desired manner. When the keyboard of the invention is combined with writing implements which include a rotating type carrier disc, the printed circuit board is preferably provided with an annular array of contact elements respectively connected with the elongated conductors referred to above. The portion of the printed circuit board carrying the conductive areas associated with the keyboard may then be arranged at a small acute angle to the horizontal in conformity with the usual orientation of the keyboard, whereas the portion carrying the array of contact elements is made upright for cooperation with one or more movable contacts mounted on the horizontal shaft of the type carrier disc coaxially with the array of contact elements, the shaft being driven by an electric motor, a V-belt, and pulleys.

The movable contact may be a finger of conductive material arranged for rotation with the type carrier disc or the pulley on the driven shaft for scanning the contact elements of the annular array. If mechanical contact with the contact elements is to be avoided for the reasons set forth above, a capacitative scanning or sensing element may be arranged on the pulley or on the type carrier disc for movement along the several contact elements on the printed circuit board.

When signals are to be transmitted from the array of contact elements by a capacitative coupling, it is preferred to provide the printed circuit board with a conductive coating or layer in the area enveloped by the array of contact elements, and to cover the interstices between the individual contact elements and between the elements and the conductive coating or layer with a resistance lacquer to provide for leakage of the stored charges.

Better control of the rate of decay of a signal applied to the array of contact elements is achieved when a grounded, conductive element is provided in the area enveloped by the contact elements, and when the interstices between the individual contact elements, and between the grounded element and the contact elements are provided with a light sensitive layer, for example, of crystalline cadmium sulfide which is made conductive by a glow discharge lamp briefly energized whenever a signal is transmitted through the array of contact elements, and arranged to illuminate the photoelectric layer.

To permit the use of the electric typewriter for the preparation of a recording on magnetic tape, it is preferred that the printed circuit board be provided with at least one additional conductive area connected with one of the contact elements of the afore-mentioned annular array by an elongated conductor, and that a recording device be provided for recording the time elapsing between the passage of the contact element connected with the additional conductive area and the initiating of an operation of the typewriter.

Further features of the invention will be explained and described hereinafter with reference to a specific embodiment illustrated in the appended drawing in which:

FIG. 1 shows an electric typewriter of the invention in fragmentary side-elevational section;
FIG. 2 shows the printed circuit board of the machine of FIG. 1 laid out in a plane; and
FIG. 3 is a schematic representation of the electric circuit of the same electric typewriter.

Referring initially to FIG. 1, which shows only as much of an electric typewriter of the invention as is necessary for an understanding of the same, includes a keyboard 1 consisting essentially of a perforated metal sheet 2 and flat cylindrical keys 3 set into the openings of the sheet 2. Annular radial flanges 4 on the keys prevent the latter from upward movement through the sheet. Pins 5 downwardly project from the several keys 3 into abutting engagement with a foil 6 of electrically conductive rubber. A perforated plate 7 of insulating material is arranged under the rubber foil 6 and is supported by a printed circuit board 8, the latter being releasably secured on the frame of the machine in a conventional manner, not shown. The frame is indicated in FIG. 1 in phantom view only.

Details of the printed circuit board are better seen in FIG. 2. A gold or silver plated conductive contact area 9 of the copper layer of the circuit is associated with each key 3 and connected with the type actuating mechanism of the typewriter by an elongated conductor portion 10 of the copper layer. The type actuating mechanism will be described more fully hereinafter.

The keyboard described so far operates as follows:

The electrically conductive rubber foil 6 is connected to one pole of a suitable source of direct current and insulated from the conductive areas 9 of the printed circuit board 8 by the perforated plate 7 as long as no key 3 is depressed. When a key is pressed, the portion of the foil adjacent the pin 5 of the pressed key 3 is deformed and is moved through the aligned opening in the plate 7 into engagement with the associated conductive area 9. The electrical contact formed thereby closes a circuit, and a signal is transmitted by the corresponding conductor 10 to the type actuating mechanism of the electric typewriter.

The rubber foil 6 engages the perforated plate 7 so as to form a practically airtight seal with the same, and the plate 7 engages the printed circuit board 8 in substantially the same manner. The contact points of the conductive areas 9 and of the rubber foil 6 are protected against contamination by dust and against moisture so as to ensure extended trouble free operation.
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In order to maintain electrical signals transmitted by the conductors 10 until the instructions given are followed in the operating mechanism of the electrical typewriter, a magnetic retaining plate may additionally be provided in the keyboard 1 for holding each key 3 in the depressed position until an electromagnet is energized or deenergized, the change in the condition of the electromagnet being coupled with the operating function of the mechanism.

If the closing of mechanical contacts in the keyboard 1 is to be avoided, piezoelectric crystals may be arranged above the conductive areas 9 for generating electric potentials in response to the pressing of the associated keys 3, the potentials being transmitted to the conductors 10 to the operating mechanism of the electric typewriter.

Electric signals in the conductors 10 may also be generated during the pressing of each key 3 by arranging a thin, electrically polarized insulating layer between the printed circuit board 8 and the individual keys 3 of the keyboard 1, the layer functioning as an electret. When a key 3 is pressed, the electret is deformed, whereby a signal is generated in the associated conductor. Suitable electrets have been described in "Funkschau 41", [10 (69) 316].

Alternatively, one may provide an insulating foil between the electrically conductive foil 6 and the printed circuit board 8, and apply a high voltage to the foil 6. When a key 3 is depressed, the deformation of the associated conductive area 9, the insulating foil, and the aligned portion of the conductive foil 6 is changed sufficiently to generate an electrical signal in the conductor 10 which may be used for initiating operating functions in the electric typewriter.

The manner of using the signals generated by pressing the individual keys 3 and transmitted by the conductors for operating a typewriter equipped with a rotary type carrier disc will now be described.

As is seen in FIG. 2, the conductors 10 lead to respective elements 11 of a contact ring 12 constitutes by a circularly annular array of the contact elements. The base material of the printed circuit board 8 is flexible so that the portion of the printed circuit equipped with the contact ring 12 may be bent into a practically upright plane as is shown in FIG. 1. A circular aperture 13 is centered in the contact ring 12, and a shaft 14 freely passes through the aperture. One axial end of the shaft fixedly supports a type carrier disc 15 formed with a multiplicity of radial slots bounding resilient tongue portions of the disc. The free ends of the tongue portions carry each a capital letter type and a lower case type. The several types may be positioned adjacent the rubber-covered cylinder 16 of the electric typewriter by turning the disc 15.

The other axial end of the shaft is connected to a pulley 17 which is connected with the drive pulley 19 of an electric motor 20 by a V-belt 18. A contact finger 21 is mounted on one face of the pulley 17 and scans the elements 11 of the contact ring 12 during rotation of the shaft 14. The other face of the pulley 17 carries a slip ring 22 conductively connected with the contact finger 21. Another finger 23 movably engages the slip ring 22 on the pulley 17. It is fixedly mounted and conductively connected with a binding post 24 which may be an input terminal of an electric amplifier.

The last described apparatus operates as follows:

The pulley 17 and the type carrier disc 15 are synchronously driven by the electric motor 20 by means of the V-belt 18, but operation of the typewriter is not initiated by such rotation. When a key 3 is pressed, an electric signal is generated as described above, and is transmitted by the associated conductor 10 to the corresponding contact element 11 of the contact ring 12. When during rotation of the pulley 17, the contact finger 21 engages the signal carrying contact element 11, the signal is transmitted by the contact finger 21 to the slip ring 22, and thence by the contact finger 23 to the binding post 24. The amplifier connected to the binding post amplifies the signal, and the amplified signal is fed to a plurality of operating devices of which only one, a solenoid 25, is shown in FIG. 1. The solenoid is deenergized by the signal transmitted to the binding post 24 so that a rocker arm 26 attached to the armature of the solenoid 25 is pivoted by a tension spring 27. A hammer 28 fastened to the end of the rocker arm 26 strikes a tongue of the type carrier disc 15, and the type on the struck tongue is impressed on the paper wrapped about the cylinder 16. Because the contact finger 21 receives a signal from the contact ring 12 in an angular position uniquely related to the pressed key 3, the pressed key and the type struck by the hammer 28 are precisely coordinated.

The flexibility of the printed circuit board 8 is additionally advantageous because it permits the assembly consisting of the type carrier disc 15 and the pulley 17 to be mounted for vertical shifting movement for a change from capital letters to lower case letters and vice versa without requiring a vertical movement of the cylinder 16.

FIG. 2 provides for mechanical contact between the contact finger 21 and the annular array 12 of contact elements 11. However, if the sensitivity of the amplifier connected to the binding post 24 is sufficient, direct mechanical contact between the finger 21 and the contact ring 12 is not needed, and may be prevented to avoid the problems inherent in contact wear. The signals may be transmitted by capacitative coupling from the conductors 10 to the slip ring 22, and from there to the rotating scanning element connected to the binding post 24 if the signal output from the printed circuit is chosen sufficiently high. The distance between the contact finger and the ring 12 of contact elements 11 may be about 0.3 mm to produce a capacitance of the order of 0.1 pF.

A controlled decay of the signal in the conductors 10 is achieved in the case of capacitative scanning by a grounded conductive layer 29 arranged centrally of the contact ring about the circular aperture 13. A conductive lacquer of high resistance is applied to the printed circuit board 8 between the individual contact elements 11 of the contact ring 12 and between the contact ring and the layer 29. The time constant of the resistances and capacitances associated with the contact ring 12 are chosen in such a manner that the charges generated in the elements 11 are available until the elements are scanned by the rotating finger 21 and the desired type has been impressed on the paper by the deenergized solenoid 25 even if the associated key 3 is depressed only momentarily.

For an even more closely controlled decay of signals on the ring 12, the high-resistance lacquer may be replaced by a coating of crystalline cadmium sulfide whose electrical resistance is strongly reduced by energizing a glow lamp whenever a signal reaches the amplifier, whereby a rapid decay of a voltage signal can be achieved.

Particularly when a signal is transmitted to the input terminal 24 of the amplifier by capacitative coupling, the input circuit of the amplifier is equipped with a field effect transistor to provide an input impedance of the order of 1011 ohms. The amplifier is further equipped with a delay circuit which permits the solenoid 25 to be energized again only after the hammer 28 has struck a section of the type carrier disc 15 and an impression has been made on the paper. The delay required may be of the order of 20 milliseconds corresponding to one-fourth to one-half revolution of the type carrier disc 15.

FIG. 3 schematically illustrates the electric circuit of a typewriter of the invention equipped for capacitative scanning of the contact ring 12. A high-voltage direct-current generator G serves as a source of signal potential, being capable of producing approximately 800 to 3,000 volts. The positive terminal of the generator G is grounded through a resistor R1. The negative terminal of the generator is connected to the conductive rubber foil 6 which, in cooperation with the conductive areas of the printed circuit board 8 forms switches T1 - T4. The switches are connected with respective contact elements 11 of the contact ring 12 by the conductors 10. The ring 12 is scanned by the rotating sensing element 21 which is connected in circuit with the amplifier terminal 24. Two amplifiers V1, V2 are respectively connected to the terminal 24.
and to the positive terminal of the generator G, and to ground. Both amplifiers have field effect transistors in their input circuits, as pointed out above, and thus have very high input impedance.

The output terminals of the amplifiers V₁, V₂ are connected to the multivibrator stages Kₜ, Kₕ of which the first produces a square-wave signal of about 20 milliseconds duration in response to a signal received, while the second multivibrator stage Kₕ produces a similar signal of about 100 milliseconds duration in response to the ascending flank of an output signal of the associated amplifier. The output terminals of the two multivibrator stages are connected to respective input terminals of an AND-gate U whose output terminal is connected to the base of an NPN transistor Tr through a resistor Rₜ and a parallel capacitor C. The collector and emitter of the transistor Tr may close a circuit from plus potential through three electromagnets or solenoids M₁ - M₃ equipped with respective decoupling diodes D₁ - D₃ to ground. One of the elements M₁ - M₃ is the solenoid 25 described with reference to FIG. 1. A voltage limiting circuit consisting of a zener diode Z₁ and diode D₃ is arranged parallel to the electromagnets M₁ - M₃ and the associated diodes D₁ - D₃ to prevent excessive voltage during the deenergizing of the electromagnets.

The electric circuit illustrated in FIG. 3 operates as follows: A high voltage is applied to the switches T₁ - T₄₈ by the generator G. When one of the switches is closed by depressing a key 3 and is applied to the corresponding contact element 11 of the element 12. When the sensing element 21 sweeps the charged element 11, a signal is transmitted to the terminal 24 and is amplified by the amplifier V₁. When the switch selected by pressing a key 3 is closed, a current flows in the resistor Rₜ and a potential difference is established across the resistor to provide an input signal for the amplifier V₂. The output signals of the two amplifiers are fed to the respective multivibrator stages Kₜ, K₅ and cause the release of square wave signals, the stage K₅ generating a signal only if the incoming signal is increasing in intensity.

The duration of the pulse generated by the multivibrator stage Kₜ is chosen in such a manner that it corresponds approximately to the duration of one revolution of the tape carrier disc 15. The two pulses of the stages Kₜ, K₅ are fed to the AND-gate which produces a blocking signal in response to the simultaneously received pulses, thereby making the transistor Tr non-conducting and deenergizing the magnets M₁ - M₃ and the diode D₃. The duration of the pulse generated by the stage K₅ being only slightly longer than one revolution of the tape carrier disc 15 and of the sensing element 21, only one letter is typed even if a key 3 associated with one of the switches T₁ - T₄₈ is pressed longer than during one revolution of the tape carrier disc because the pulse of the stage K₅ terminates abruptly, and the transistor Tr cannot be blocked again.

As is further shown in FIG. 2, two additional conductive areas 30 not associated with keys of the keyboard 1 are provided in the portion of the printed circuit board 8 which is below the contact ring 12 in the installed position of the board 8, and are connected with contact elements 11 of the contact ring 12. The conductive areas 30 and the associated contact elements serve for special operations, and permit the written text to be stored on magnetic sound recording tape. For this purpose, the intervals between the traverse of the sensing element 21 over the contact element 11 associated with one of the two conductive areas 30 and the time of a type selecting step are recorded, the interval being characteristic of and uniquely correlated with each letter. The signal employed may be selected from the high end of the low frequency range. For simpler processing of speech and sound recording tape, it is preferred to record a synchronizing pulse on a separate track simultaneously with the passage of the sensing element over one of the contact elements associated with the two conductive areas 30.

The synchronizing pulse may be derived, for example, from a small permanent magnet which is mounted on the V-belt pulley 17 near the periphery of the latter. A coil is fixedly mounted on the typewriter frame within range of the moving magnet so that pulses are generated in the coil and may be recorded as synchronization signals.

To permit transcribing of a legible text from a sound recording tape so prepared, the tape transporting motor may be controlled in such a manner that the synchronizing pulses stored in the tape occur simultaneously with the synchronizing pulses occurring in the electric typewriter. The speed of the recording tape may be adjusted even better to the rotary speed of the type carrier disc 15 by means of planetary gearing driven by a servo motor. It is generally preferred to employ a multi-track recording tape to provide not only a pulse track and a synchronizing track, but also tracks for recording other operations of the machine, such as the functions of the spacer bar, the shift key, the carriage return, the line spacing key, and the like.

Instead of a multi-track recording tape, a single-track tape may be employed if the frequency of the recording signal is changed, for example, from 5 to 6 kHz, the other lower case from capital letters. The control signals for carriage return, line spacing, and the like may be recorded by superimposed low-frequency signals on the same track.

When the electric typewriter of the invention is provided with such a recording device for magnetic sound recording tape which is preferably equipped with conventional tape cassettes, the typewriter may be employed for automatically typi ng multiple copies of letters, or as a transmitter or receiver for a teletype system. The synchronization of the teletype transmitter with a remote teletype receiver may be achieved by reference to the phase of a common power grid. When the typewriter is employed for automatically typing multiple letters it is preferred that the recording tape may be advanced stepwise during recording, and to control the tape transport in response to the entry of operating signals. Such an arrangement not only increases the signal density on the recording medium, but it also produces a higher writing speed during reproduction of the recorded text.

Instead of the high-voltage direct-current generator G shown in FIG. 3, an alternating current generator may be employed whose frequency is at the high end of the low frequency range, for example, 15 kHz. When an alternating potential is employed, its numerical magnitude may be reduced to as little as 200 volts. The use of alternating potential in the high end of the flow-frequency range is particularly advantageous because it avoids sporadically occurring tension potentials which may cause malfunctioning.

The printed circuit board shown in FIG. 2 may be provided with an additional flat, metallic conductor arranged on insulators so as spacedly to intersect the conductors 10, and may be connected directly with the multivibrator stage K₅. This permits a shorter blocking time to be achieved, whereby higher writing speeds become possible.

To avoid malfunctioning when two different keys 3 are pressed in quick succession, an additional deenergizing circuit may be provided which briefly separates the high voltage generator G from the other elements as soon as a key 3 has been pressed. Instead of electrically blocking the individual keys 3 to prevent them from being pressed too quickly one after the other, they may also be locked mechanically by providing a ball lock of known design in the keyboard 1 which permits only one key 3 to be pressed.

It is preferred to mount the keyboard 1 releasably on the machine frame so that the keyboard may be replaced by another keyboard having keys marked with different type symbols when the type carrier disc 15 is replaced to provide special types of recording tape.

When the individual keys operate by capacitance changes, the changes caused by approaching or engaging fingers may be relied upon, and movable keys are unnecessary. In such an arrangement, the conductive areas 9 of the printed
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circuit board 8 are arranged on the underside of the insulating base of the board 8, and the typewriter is operated by placing the fingers with or without pressure on the base of the printed circuit board above the conductive areas 9, whereby electrical pulses are generated in the conductors 10 and may initiate the operation of the typewriter as described above.

What is claimed is:
1. In an electric typewriter having a keyboard including a plurality of movable keys, a cylinder adapted to carry a paper wrapped about the cylinder, a plurality of types mounted for forming impressions on said paper, and an operating mechanism connecting said keyboard to said types, the improvement which comprises:
   a. a printed circuit board having an insulating base of flexible material and a plurality of conductive areas respectively aligned on said base with said keys in the direction of movement of said keys;
   b. a plurality of elongated conductors respectively connected to said conductive areas;
   c. signal generating means for generating an electric signal in each of said areas and the associated conductors in response to said movement of the aligned key;
   d. said signal generating means including an electrically insulating foil and an electrically conductive foil interposed between said keys and said printed circuit board, said insulating foil being interposed between said conductive foil and said printed circuit board, said foils and said conductive areas jointly constituting a plurality of capacitors each responsive to movement of said keys toward said printed circuit board for changing the capacitance thereof, said capacitance change constituting said signal;
   e. a shaft coaxially passing through said array;
   f. a motor connected to said shaft for continuously rotating the shaft at a predetermined speed; and
   g. a type carrier disc mounted on said shaft for rotation thereby, said types being mounted on said disc.
2. In a typewriter as set forth in claim 1, said signal generating means including a foil of conductive elastomeric material interposed between said keys and said conductive areas and sealing said areas from the ambient atmosphere.
3. In a typewriter as set forth in claim 1, an electrically conductive resilient foil and an electrically insulating perforated plate interposed between said keys and said printed circuit board, the foil being interposed between the keys and the plate, the perforations of the plate being aligned with said keys and said conductive areas, respective portions of said foil being moved through said perforations toward said conductive areas when said keys are moved toward said printed circuit board.
4. In a typewriter as set forth in claim 1, a sensing element mounted on said shaft for rotation therewith and for scanning said contact elements, said sensing element engaging the scanned contact elements.
5. In a typewriter as set forth in claim 1, a sensing element mounted on said shaft for rotation therewith and for scanning said contact elements, said sensing element being spaced a small distance from the scanned contact elements during said rotation thereof for capacitative coupling therewith.
6. In a typewriter as set forth in claim 5, a conductive layer on said printed circuit board and enveloped by said annular array, a coating of high-resistance conductive lacquer on said printed circuit board extending between said contact elements and between said array and said conductive layer.
7. In a typewriter as set forth in claim 5, said amplifier means including a first amplifier having a field effect transistor in the input circuit thereof, said input circuit being connected to said sensing element, a first monostable multivibrator connected to said amplifier for receiving the output signal of said amplifier and responsive to the received output signal for generating a first square wave pulse for transmission to said operating mechanism.
8. In a typewriter as set forth in claim 7, said signal generating means further including a high-voltage generator conductively connected to said electrically conductive foil and in a series circuit with a resistor, said amplifier means including a second amplifier connected to said resistor for producing an amplified output signal in response to current flow through said resistor, a second monostable multivibrator connected to said second amplifier and responsive to the rising flank of said amplified signal for producing a square wave pulse having a duration slightly greater than one revolution of said shaft.
9. In a typewriter as set forth in claim 8, an AND gate having two input terminals respectively connected to said monostable multivibrators for receiving said square wave pulses of the same, and an output terminal, and responsive to simultaneous pulses from said first and second monostable multivibrators for generating an output signal, a transistor having a base conductively connected to said output terminal of said AND gate and responsive to the output signal of said AND gate for blocking the emitter-collector circuit thereof, said operating means including an electromagnetic operating member in said emitter-collector circuit.
10. In a typewriter as set forth in claim 9, a decoupling diode in series circuit with said operating member, and voltage limiting means including a zener diode and a diode in parallel circuit with said operating member and said decoupling diode.