

(No Model.)

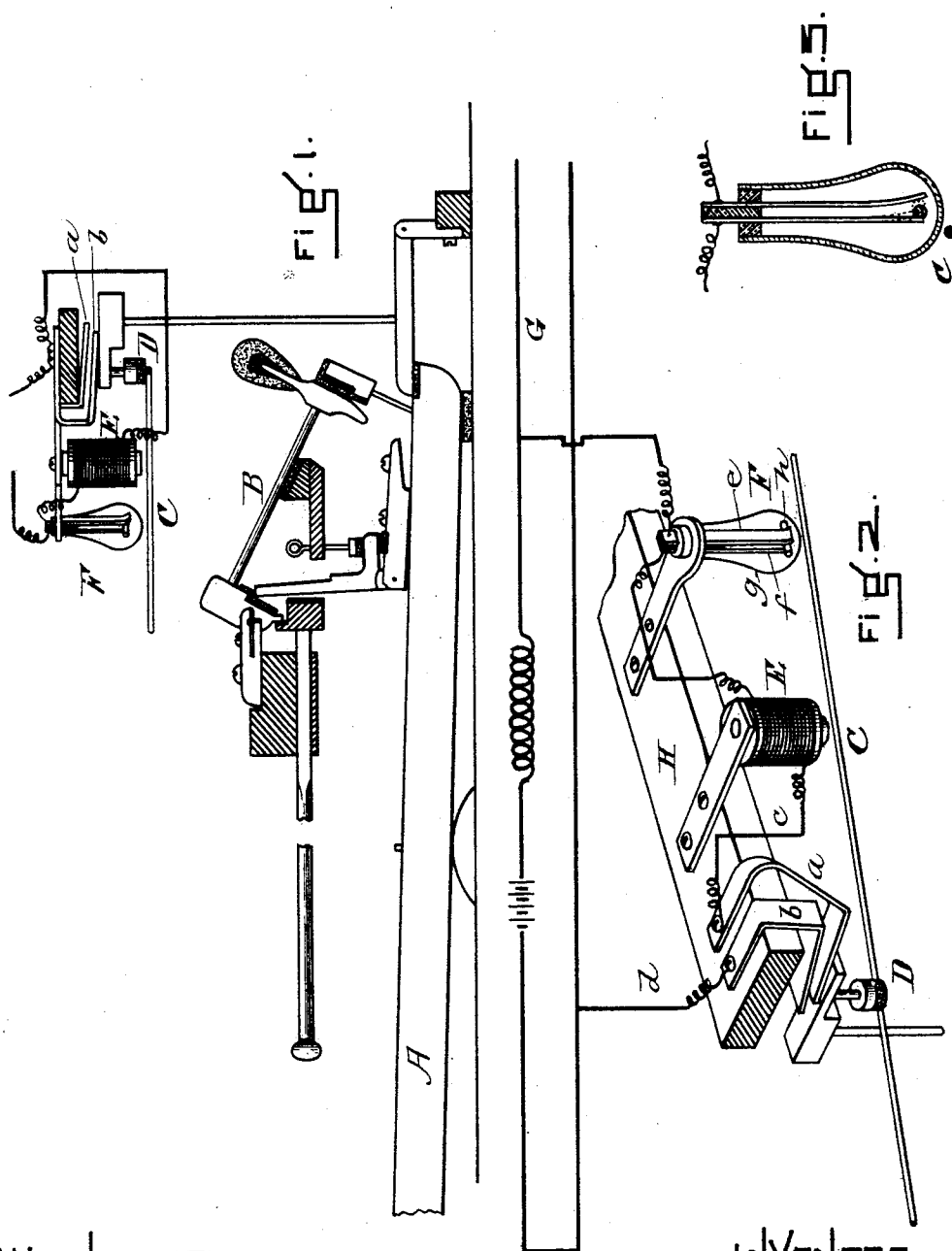
3 Sheets—Sheet 1.

E. C. OHMART.

METHOD OF AND APPARATUS FOR PRODUCING MUSICAL TONES BY
ELECTRO MAGNETISM.

No. 472,019.

Patented Mar. 29, 1892.



WITNESSES

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(No Model.)

3 Sheets—Sheet 2.

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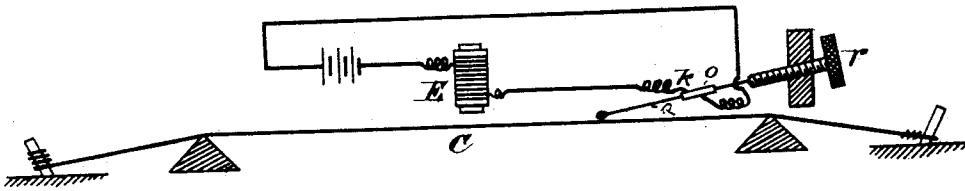


Fig. 4.

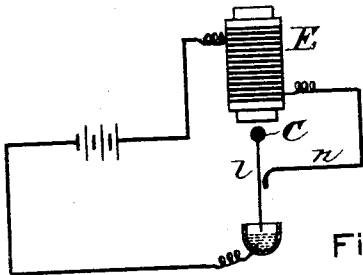


Fig. 5.

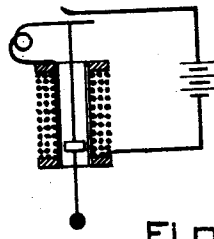


Fig. 6.

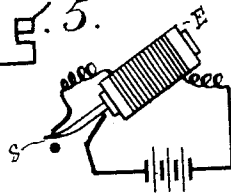


Fig. 12.

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(No Model.)

3 Sheets—Sheet 3.

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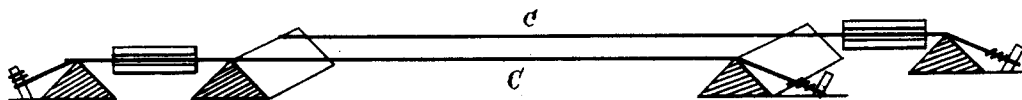


Fig. 7.

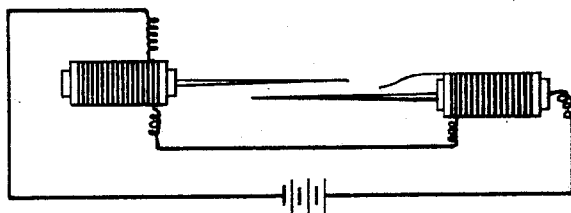


Fig. 8.

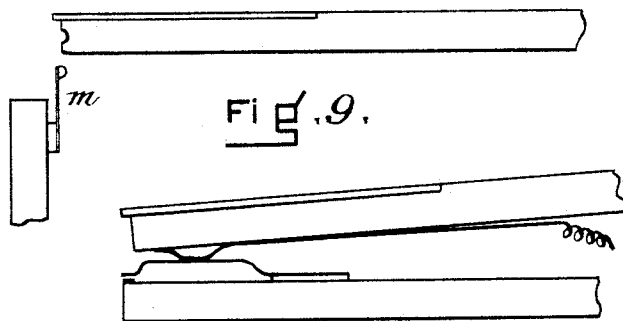


Fig. 9.

Fig. 10.

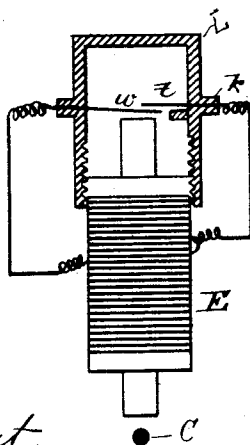


Fig. 11.

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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR PRODUCING MUSICAL TONES BY ELECTRO-MAGNETISM.

SPECIFICATION forming part of Letters Patent No. 472,019, dated March 29, 1892.

Application filed April 28, 1890. Serial No. 349,802. (No model.)

To all whom it may concern:

Be it known that I, ELI C. OHMART, of Detroit, in the county of Wayne and State of Michigan, have invented a new and useful Improvement in Methods of and Apparatus for Producing Musical Tones by Electro-Magnetism, of which the following, taken in connection with the accompanying drawings, is a specification.

In a keyed stringed musical instrument the blow of the hammer upon a wire obliterates a certain harmonic of that wire and prevents what would be the natural oscillation of the wire. The localized influence of the hammer, producing an abnormal oscillation, gradually subsides and the oscillation becomes normal, and the wire, recovering from the local effect of the percussion, regains its normal nodes and transverse swings after having wasted energy in overcoming the tendency to abnormal oscillation, and thus a rapid change of timbre from first to last is produced. The percussion upon the wire, in addition to producing a note whose pitch depends upon the length, thickness, and tension of the wire, also produces a note whose pitch depends upon the mass of the wire, and this pitch bears no relation to the pitch due to the length, thickness, and tension of the wire, but is discordant thereto. This is a marked defect in keyed instruments as now made. The effect of percussion upon the wire also produces a modulation in the tone due to differences in the amplitude of oscillation, and, commencing with a percussive thump, the tone gradually diminishes from first to last, introducing various discords, and owing to the sympathetic reinforcement by the sounding-board of the volume of the discordant tones and the sympathetic vibration of adjacent wires a chaos of discords is produced when two or three notes not in harmony are sounded in proximity to the sounding-board. It is therefore desirable to secure increase of volume by other means than increase in the percussive effect. In keyed stringed instruments the upper notes are produced by two or three unison-strings, whose aggregate length is much less than that of the strings producing the lower notes and whose volume is therefore much

less, and therefore not only does the timbre and amplitude vary from first to last in any given note for the reason before set forth, but the volume of tone in the various notes decreases from the lowest pitch to the highest. It is desirable that keyed stringed instruments should be made which will be free from these defects and in which the timbre and volume of each note may be rendered constant from first to last when desired. Pianissimo and fortissimo playing is accomplished by methods which either muffle a loud tone instead of producing a soft tone or by changes in the force of percussion, thereby altering the timbre, as before explained, or by striking the keys with such force as to mingle with a comparatively pure tone a discordant metallic clang, or, as is the case with all pianos, by lifting the dampers from the wires, thereby producing sympathetic discordant oscillations in juxtaposed wires free to oscillate sympathetically. The invariable diminuendo of the volume of all tones and the invariable change in the tone quality in every note from first to last are a monotonous iteration inconsistent with definite emotional expression or the proper interpretation of musical compositions.

The object of the invention which forms the subject of this application for Letters Patent of the United States is the production of a musical instrument in which the before-mentioned defects will be obviated; and I propose to accomplish this result by the method of and apparatus for producing, prolonging, and modulating musical tones by electrical means, as hereinafter described.

My invention therefore consists, first, in the method of and apparatus for vibrating, substantially as hereinafter more fully set forth, any sonorous body to produce musical tones by means of electric devices acting to cause, continue, or modify the vibrations of the sonorous bodies when the interruptions or variations in the current are produced automatically through these devices by circuit-interrupting or current-varying devices operated by the periodic vibration of the sonorous body or some sonorous body vibrating in unison therewith and when this circuit does not

include the sonorous body acted upon; second, in the method of and apparatus for prolonging, substantially as hereinafter more fully set forth, the musical tones thus produced by continuing the action of the electric devices operating to produce the tones; third, in the method of and apparatus for modulating, substantially as hereinafter more fully set forth, the tones thus produced by varying the power of the electric devices acting to vibrate the sonorous bodies producing the tones; fourth, in the combination, substantially as hereinafter more fully set forth, with the electric devices and the vibrating sonorous bodies acted upon thereby, of circuit-interrupting or current-varying devices, as described, which maintain the current during the movement of the vibrating body in one direction and interrupt the current or diminish its strength during the movement of the vibrating body in the other direction; fifth, in the combination, substantially as hereinafter more fully set forth, with the circuit-interrupting and current-varying devices, of means for inclosing these devices in a vacuum; sixth, in the arrangement, substantially as hereinafter more fully set forth, in multiple arc of the electric devices acting upon the sonorous bodies, whereby each electric device acts upon the sonorous vibrating body actuated thereby with the same power, no matter what may be the number of electric devices brought into action at the same time from a single source of electric energy.

In the accompanying drawings I have shown the principle of my invention as embodied in a keyed stringed instrument and my method of producing, prolonging, and modulating musical tones by electricity as applied to the strings of a piano, and I have shown these strings as vibrated by the attraction of an electro-magnet; but the invention can be carried into effect for vibrating reeds which produce musical tones by their own vibration or by the vibration due to the action of the vibrating reed upon columns of air in pipes, or for vibrating disks and diaphragms, or for vibrating any other sonorous body; but in view of other prior inventions—as, for example, those of Elisha Gray—I only claim this method as applied to reeds when the reed does not form part of the electric circuit, and I regard this as an important distinction for the reason that the effect of the passage of the electric circuit through the reed is to modify its tone, destroy its elasticity, and cause a rattling.

In the accompanying drawings, Figure 1 is a sectional view showing the piano-action and the electro-magnet acting on the string. Fig. 2 is a view in elevation of the string, the electro-magnet, and the circuit-breaking device. Fig. 3 is an enlarged view of the circuit-breaking device. Fig. 4 shows a device in which the contact-point bears upon a conducting-plate attached to a stretched string of silk or other non-conducting material attached to the wire.

Fig. 5 is a view of a device in which contact is interrupted or varied by means of a fine wire attached at right angles to the vibrating body and making contact with mercury. Fig. 6 shows the string attached to a bar moving within a solenoid. Fig. 7 shows two magnetized unison-wires, whereby the wires are caused to exercise a mutual attraction and repulsion. Fig. 8 shows two parallel magnetized reeds of opposite polarity acting upon one another. Fig. 9 shows a device for holding down a key. Fig. 10 shows the device for increasing the surfaces of contact of the circuit devices at the keys, whereby the strength of the magnetic attraction upon the wire is increased. Fig. 11 shows an electro-magnet one pole of which attracts the wire or reed and the other pole operates the circuit-breaking device. Fig. 12 shows an electro-magnet having an elastic flexible pole which acts at the same time to attract the wire and to interrupt or vary the current.

Referring to Figs. 1, 2, and 3, which show a practical embodiment of the principle of my invention, A is a piano-key lever. B is the hammer and mechanism connected therewith. C is the piano-string. D is the damper. E is the electro-magnet which attracts the string. F is the circuit-interrupting device. G is the circuit, in which the electro-magnet operating on the string is shown as connected in multiple arc. A convenient device for closing the circuit through the electro-magnet consists in the arrangement of two metallic springs *a* and *b*, the ends of which are attached to a bar H, which extends above each string and to which are attached the electro-magnet E and the circuit-closing device. These springs are insulated from one another, and to one spring is attached a wire *c*, forming a part of the circuit through the electro-magnet E, and to the other is attached a wire *d*, which is connected to one of the wires of the main circuit G. The other ends of these springs lie one above the other between the damper and the bar H, and thus when the damper is thrown up by the depression of the key the ends of the springs are pressed together and the circuit is completed through the electro-magnet E. Other devices may be used for completing this circuit—as, for example, contacts on the keys or suitable contacts operated by the keys.

The circuit-interrupting device consists of a metallic spring *e* and a metallic bar *f*, sealed in a bulb *g* and insulated from one another, and from which bulb the air is exhausted. The bar has attached to its lower end a piece *h* of iron or of magnetized steel, which is in close proximity to the metallic piano-string and which is also in contact with the spring, so that the circuit is closed.

When the circuit is completed through the electro-magnet E by the depression of the key, the magnet exerts an attractive force upon the wire, and when the wire approaches the iron or steel piece *h* this bar is in turn attracted toward the wire and the circuit formed

by the contact of the spring *e* and bar *f* is broken. The piece *h* is so placed that it bears against the end of the spring *f*, so that when the bar is attracted the end of the spring *f* may follow the movement and the circuit will not be immediately broken, thus affording time for the magnet to exert its full power upon the wire. When the wire by its elasticity swings away from the magnet to the extent determined by the tension and length of the wire, the magnetized piece *h* ceases to be sufficiently effected by the wire to be attracted, the circuit through the spring *e* and bar *f* is again completed, and the magnet again acts to attract the wire. A movement of vibration is thus given to the wire, which movement continues as long as the circuit remains closed by the depression of the key, and a musical note is produced of a pitch determined by the length, thickness, and tension of the wire. If the piano-string is of a non-magnetic metal or of catgut or other similar non-magnetic material, a piece of iron or steel may be placed on the string under the electro-magnet, or a fine steel or iron wire may be wound upon the string at that point.

It may be desirable that the wire or other sonorous body should not form part of the circuit, and when this is the case other devices for interrupting or varying the current besides that shown in Fig. 3 can be used. Forms of these devices are shown in Figs. 4, 5, 6, and 8.

In the device shown in Fig. 5 a fine platinum wire *l* is attached to the vibrating string at right angles to the same and dips into a cup of mercury, which forms part of the circuit, this circuit being completed by a fine spring *n*, which is attached to or slides upon the platinum wire.

In the device shown in Fig. 4 the contact-breaking points *k* slide upon a plate of metal *o* on a string *p* of silk or other insulating material attached to the vibrating wire and maintained at a tension by means of a screw *r*, to which it is attached. In order that the least modification in the tone of the wire may be produced, the fine string is attached at a slight angle to the vibrating string.

Fig. 12 shows an electro-magnet *E* for attracting the wire, which electro-magnet has an attracting-pole, which terminates in a flexible point *s*. When the circuit-breaking point bears upon this flexible pole and when the wire is attracted, the flexible point is also attracted to such an extent as to interrupt the current or diminish its strength.

In the device shown in Fig. 11 the electro-magnet *E*, besides attracting the wire, attracts by its opposite pole two springs *t w* of magnetic metal, connected in the circuit through the electro-magnet and each fixed by one end to a suitable support *k* and each having the other end free. These free ends are normally in contact with one another, so that the circuit is thus closed. These springs are

of different length, and consequently when the springs are attracted they will follow each other and remain in contact for a short time only, and when they separate the circuit through the electro-magnet will be broken, so that the springs will again come into contact with one another. In order to prevent the rattling caused by the vibration of these springs from mingling with the tone due to the vibration of the wire or reed or other sonorous body, the circuit-breaking springs may be placed in a box *L*, lined with felt, or the same result may be accomplished by placing the springs in a vacuum. Placing the circuit-interrupting springs in a vacuum will also prevent the sparking when the circuit is broken. It may be sometimes desirable to put a condenser in the circuit for the purpose of preventing sparking.

It is obvious that many other forms of circuit interrupting and varying devices can be made by which the intermittent interruption in the circuit or the variations in the strength of the current are controlled by the periodic motions of the sonorous body producing the tone, and my invention can be carried into effect by the use of any one of these forms.

I do not limit my invention to the vibration of the sonorous body by the action of an electro-magnet upon the same; but I can also use a solenoid in the core of which a piece of iron which is attached by a string to the vibrating wire is made to move by the variation or interruption in the current in the solenoid due to the action of the circuit interrupting or varying device operated by the vibrating sonorous body, as before explained, as shown in Fig. 6. I can also produce vibrations in wires or reeds by the attraction and repulsion caused by the effect upon one another of electric currents in these wires or reeds, or these wires or reeds can be rendered magnetic by induction by the action upon them of solenoids, as shown in Fig. 7. Intermittent changes of static electricity controlled by the vibrations of the sonorous body can also be used to produce musical vibrations. This method of vibrating the strings of a piano can be used separately or can be used with a piano of ordinary construction, so that the present percussive effects can be obtained and the electrical method can be used to prolong and modulate the tone produced, or the electrical and percussive methods can be used separately on the same instrument and means be provided to bring the electrical apparatus into action.

The tone may be prolonged at will by holding the keys down, and a device may be provided, as shown in Fig. 9, for holding a key down after it has been depressed, thus enabling the fingers to be used on the other keys. This device consists of a catch *m*, which is arranged in such relation to a notch in the end of the key that when the key is depressed the catch can be made to enter or

leave this notch by suitable mechanism—as, for instance, a pedal or knee-swell—and hold the key down.

The tone produced can be augmented or diminished by increasing or diminishing the power of the attracting or repelling electrical forces acting on the sonorous body to cause its vibration. This may be done in several ways.

Mechanism operated by the knee or foot or in any other manner may operate to cause the greater or less immersion of the zines of the battery, may act to throw other batteries in or out of circuit, may operate to introduce or take out resistances, may act to alter the distance of the operating electro-magnet from the sonorous bodies acted upon, or to cause variation in the pressure of the contact-points of the circuit interrupting or varying devices, or to cause them to follow the vibrating wire through a longer swing.

The loudness of any individual note may be increased or diminished by varying the contact-surfaces operated by the pressure of the key or the pressure between these contact-surfaces, as shown in Fig. 10. It may also be accomplished by increasing the battery-power, by interposing in or removing from the circuit resistances, or by varying the distance of the magnet from the vibrating wire. Many other methods of accomplishing this result will suggest themselves.

Each one of the electro-magnets or solenoids acting upon the sonorous bodies may be connected to a separate battery or batteries, which latter arrangement will permit of an increase in the power of the current when it is desired to augment the tone, or there may be a fewer number of batteries and a commutating device so arranged and operating that no matter on what part of the keyboard the keys are struck they will be connected with a battery or batteries not in circuit. Another and preferable method is to have but one battery or source of electricity of constant potential and to connect the electro-magnets to the main wires in multiple arc, whereby the electro-motive force at the terminals of each magnet will always be the same, and as the resistance of the circuit decreases proportionally to the number of magnets in circuit the strength of the current in each magnet will always be constant no matter how many of the magnets are connected to the main conductor. This method of maintaining a current of constant strength in a number of transformers of electric energy—as, for example, incandescent lamps supplied at a constant potential—is well known.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. The method, substantially as and for the purpose set forth, of producing musical tones, which method consists in producing musical vibrations in strings, wires, reeds, diaphragms,

or any other sonorous body by the action upon these bodies of attracting or repelling forces produced in electro-magnetic or inductive devices by intermittent impulses of electricity, either pulsatory or undulatory, corresponding in frequency to the number of vibrations, being a multiple or sub-multiple thereof, in the musical tone produced by the vibrating sonorous body and automatically determined by the movements of the sonorous vibrating body and when the circuit conveying these intermittent, pulsatory, or undulatory electric impulses does not include the vibrating body.

2. The combination, substantially as and for the purpose set forth, of a sonorous body capable of vibrating to produce a musical tone, an electric device acting upon said sonorous body to attract or repel the same, a source of electric energy supplying a current to this electric device, an electric circuit from this source of energy and including the electric device, but not including the sonorous body, normally open, a device operated by a key or otherwise for closing this circuit, and a device operated by the movement of the sonorous body to produce in the electric device acting on the sonorous body intermittent impulses of electricity, either pulsatory or undulatory, corresponding in frequency to the number of vibrations in the note produced by the sonorous body.

3. In a keyed stringed musical instrument, the combination, substantially as and for the purpose set forth, of a series of strings or wires, a series of electric devices acting upon each of these strings or wires, respectively, to attract or repel the same, a source of electricity, an independent electric circuit through each of these electric devices, normally open, a device operated by the depression of the key corresponding to each of these wires to close this circuit, and a device operating by the movement of the string to produce intermittent impulses of electricity, either pulsatory or undulatory, corresponding in frequency to the number of vibrations in the note produced by this sonorous body when the circuit through the said device does not include the vibrating sonorous body.

4. The combination, substantially as and for the purpose set forth, of a string or reed vibrated electrically and a device for interrupting the current or for varying the strength of the same and operated by the movement of the reed or string and acting to continue the current during the movement of the string or reed toward the attracting device and to interrupt the current or to diminish the strength of the same at the completion of this movement and during the movement of the string or reed away from the attracting device when the circuit through the said device does not include the vibrating sonorous body.

5. The combination, substantially as and for the purpose set forth, of a wire or string

C, the electric device acting upon the same, the electric circuit through this device, the bar *f* and spring *e*, included in this circuit and insulated from each other at one end, but
5 normally in contact at the other end, and the piece of iron or steel *h* in the end of the bar *f* and in such proximity to the wire or string C that when this wire or string approaches the piece *h* the piece will be attracted to the
10 wire and will separate from the spring *e*, thus breaking the circuit.

6. The combination, substantially as and for the purpose hereinafter more fully set forth, of the electric circuit G and contacts
15 operated by the key, which contacts can be

made to have at will a greater or less amount of surface in contact and pressure.

7. The combination, substantially as and for the purpose set forth, with the key, of a notch on the end of the same, the vertical bar 20 operated by the pedal, the spring *m* on said bar, and the projection on the spring.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

E. C. OHMART.

Witnesses:

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