April 10, 1934. C. STANSBURY 1,954,029

ELECTRIC HAMMER

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Fig. 1

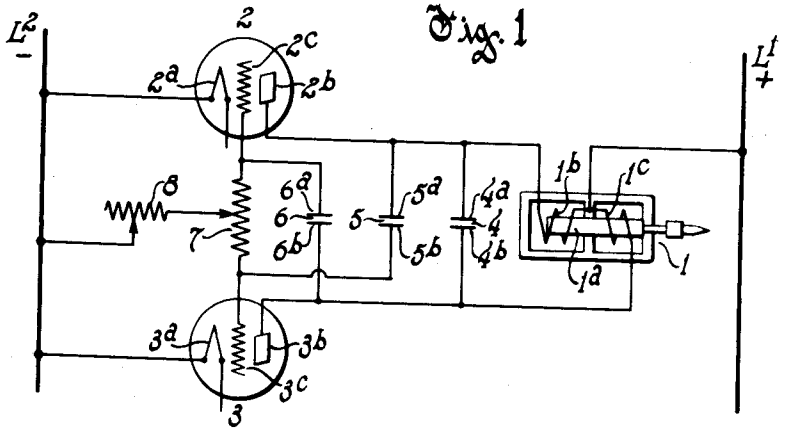
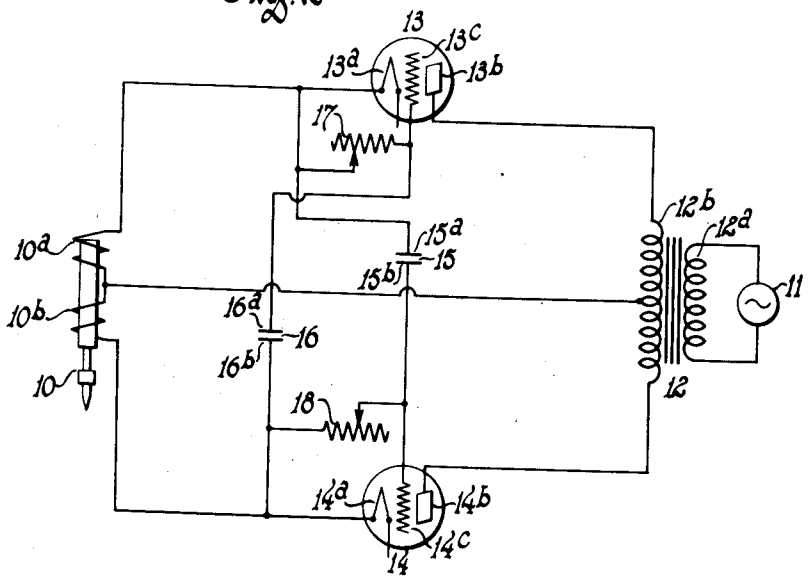


Fig. 2



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ELECTRIC HAMMER

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8 Claims. (Cl. 172—240)

This invention relates to improvements in electromagnetically operated reciprocating devices such as electric hammers.

With electric hammers it is desirable to have the energy input during the forward and return strokes just balance the work to be performed or else return any excess energy to the power supply. However, for efficient operation it is preferable that the input during each stroke just balance the load requirement, as the return of power to the supply involves additional losses in the magnetic and electric circuits of the device, and thus reduces the maximum available output for a given size and weight of the device.

Furthermore, as the power required for the forward stroke is usually much greater than that for the return stroke, it is desirable to make the input for the two half cycles different, whereby it is possible to save power and thus further increase the efficiency of the hammer. It is also sometimes desirable to control the frequency of operation of the hammer to best adapt it for the work at hand.

Where only direct current is available it has in the past been customary to employ mechanical switches for commutating the hammer circuits, but these have proved unsatisfactory on account of the heavy sparking and resulting quick deterioration produced by the highly inductive currents which have to be commutated. Electronic rectifiers have been proposed to take the place of these switches, but the systems used up to the present do not permit of control of the energy for both strokes as discussed heretofore.

The present invention has among its objects to provide for separate and accurate control of the power for the forward and reverse strokes of the hammer.

Another object is to provide for the elimination of all mechanical switching devices for commutating the current supplied to the windings of the hammer.

Another object is to provide for operation of a hammer by energy derived from a direct current source by employing electron discharge tubes for commutating the direct current.

Another object is to provide for control of the frequency of operation of an electric hammer.

Another object is to provide for separate or joint adjustments of the periods during which current flows in the different windings of the hammer.

Another object is to provide for separate adjustments of the energy supplied to the different windings of the hammer.

Various other objects and advantages of the invention will hereinafter appear.

The control herein proposed enables utilization to advantage of features of control disclosed in my co-pending application Serial No. 509,551 filed January 16, 1931, said co-pending application disclosing and claiming a method and system of control capable of various uses whereas the present application as aforestated is directed to control for electric hammers and the like.

The accompanying drawing illustrates two modifications of the invention, but the invention is subject to various other modifications within the scope of the specification and appended claims.

In the drawing,

Figure 1 is a diagram illustrating the invention applied to the control of a hammer which is supplied with power from a unidirectional power supply circuit, such as a direct current circuit, while

Fig. 2 illustrates the invention as applied to a hammer which is supplied with energy from an alternating current source.

Referring to Fig. 1, L^1 and L^2 are respectively the positive and negative terminals of a direct current supply circuit. 1 is a reciprocating electromagnetic hammer having an armature or plunger 1^a which is alternately moved in opposite directions by current flowing through windings 1^b and 1^c. The structure of the hammer may be of any suitable well known type, and forms no part of the present invention. In series with the windings 1^b and 1^c are respectively the gaseous electron tubes 2 and 3. The tubes are provided respectively with heated cathodes 2^a and 3^a, anodes 2^b and 3^b and grids 2^c and 3^c. The anodes are connected to their respective windings, both of which are connected to the positive line. The cathodes of the two tubes are connected to the negative line. A condenser 4 is connected across the two anodes, a condenser 5 is connected between the anode 2^b and the grid 3^c, and a condenser 6 is connected between the anode 3^b and the grid 2^c. A potentiometer resistance 7 is interposed between the grids 2^c and 3^c, while its adjustable contact is connected in series with a variable impedance 8 to the negative line.

The system Fig. 1 operates as follows:

If the terminals L^1, L^2 are energized the potential between them is impressed upon the main electrodes of the tubes 2 and 3. At the moment of closure of the circuit the grids 2^c and 3^c have the potential of their respective cathodes and have therefore no effect upon the discharge charac-

teristics of the tubes. The tubes employed usually exhibit slight differences in their discharge characteristics, which is due to unavoidable manufacturing variations. They therefore start to pass current at slightly different voltages. Also the impedances of the two coils 1^c and 1^b differ slightly from each other. The initial voltage wave impressed upon the main electrodes of the two tubes will therefore initiate current flow through one tube in advance of the other. Let it be assumed that current first begins to flow in tube 2. The instantaneous voltage at which current flow starts is somewhat above the drop of potential between the anode and cathode after current flow is established. Hence as soon as tube 2 conducts current the potential of anode 2^b and with it that of condenser plate 4^a is lowered so as to be negative with respect to L^1, causing a corresponding drop of the potential of condenser plate 4^b and anode 3^b, with the result that the voltage between cathode 3^a and anode 3^b is momentarily too low to permit the start of a discharge through tube 3. The current through tube 2 and winding 1^b attracts the plunger, moving it to the left, thereby decreasing at the same time the impedance of coil 1^c. After some time the current in coil 1^b becomes steady so that the potential of the plate 4^b and that of anode 3^b again approaches that of the line L^1, whereupon tube 3 becomes conducting. Current then flows through winding 1^c and causes the plunger 1^a to move to the right and drive the tool of the hammer into the work. The sudden flow of current through tube 3 reduces the potential of plate 4^b, and this causes a corresponding reduction of the potential of plate 4^a and anode 2^b to a value which momentarily stops the flow of current through tube 2 and coil 1^b.

The sudden flow of current through tube 3 also changes the potential of condenser plate 6^b, which was that of line L^1, to a lower value, resulting in a corresponding drop of the potential of plate 6^a and grid 2^c to a value which is highly negative in respect of the cathode 2^a. As long as grid 2^c is negative with respect to its cathode 2^a current flow through tube 2 cannot be reestablished. The charge of condenser 6, however, gradually leaks off from plate 6^b through anode 3^b, cathode 3^a, line L^2, resistances 8 and 7 to plate 6^a, thereby reducing the negative potential of grid 2^c, and thus permitting the tube 2 to again conduct current. As soon as tube 2 again carries current the latter energizes coil 1^b and moves the plunger to the left, while simultaneously by action similar to the aforedescribed, flow of current through tube 3 is stopped, its grid 3^c being subjected to a transient potential due to the charging of the condenser 5. Thus the tubes alternately supply current to the windings 1^b and 1^c and produce a reciprocating movement of the plunger of the hammer.

It is apparent that the rate of discharge of the grid circuits depends upon the capacities of the condensers and the value of the discharge resistances in circuit therewith. By increasing the resistance 8 the discharge time of both grids and therefore the length of both alternate periods of current is increased, i. e. the frequency of operation of the hammer is decreased, and vice versa. If the movable contact of resistance 7 is moved towards the grid 2^c, the period during which tube 2 is conducting is lengthened and that of tube 3 is shortened and vice versa. Thus the energies which are delivered to the plunger for the forward and return stroke respectively may be varied individually to adapt the operation to the particular work and thus improve the efficiency of the hammer.

Fig. 2 is a system which is particularly adapted for the control of a hammer or other reciprocating electromagnetic device when supplied with energy from an alternating current source.

A hammer 10 having the magnet coils 10^a and 10^b is supplied with energy from an alternating current source 11 through a transformer 12, having a primary winding 12^a connected to said source and a secondary winding 12^b, which latter is provided with a center tap. In circuit with the winding 10^a is a gaseous electron tube 13, which connects one terminal of said winding to one of the outer terminals of the winding 12^b. A similar tube 14 connects one terminal of coil 10^b to the other outer terminal of the winding 12^b, while the adjacent ends of coils 10^a and 10^b are jointly connected to the center tap of winding 12^b. The tubes 13 and 14 have respectively cathodes 13^a and 14^a, anodes 13^b and 14^b and grids 13^c and 14^c. Connected between the grid 14^c and the cathode 13^a is a condenser 15 and a similar condenser 16 is connected between the grid 13^c and the cathode 14^a. An adjustable impedance 17 which is preferably non-inductive is shunted across the cathode 13^a and grid 13^c, and a similar impedance is shunted across the cathode 14^a and grid 14^c.

The system illustrated in Fig. 2 operates as follows:

When no current flows in the transformer windings the grids 13^c and 14^c have the potential of their respective cathodes and are therefore incapable of stopping the flow of current through the tube when a potential difference which makes the respective anodes positive with respect to the cathodes is impressed upon them. If, therefore, the transformer is energized by closure of its primary circuit, that tube whose anode potential is positive with respect to its cathode will conduct a current which flows through the respective hammer winding and attracts the plunger as described in connection with Fig. 1. Supposing that at the moment of closure of the transformer circuit the voltage of the end of the secondary winding which is connected to anode 13^b is positive with respect to the other end, then a current flows through tube 13, winding 10^a and to the center tap of the transformer secondary winding, while no current can flow through tube 14, because its anode is negative with respect to its cathode. Condenser plate 15^a has approximately the potential of cathode 13^a and is therefore positive with respect to the center tap and grid 14^c which has the same potential. A charge is therefore accumulated by condenser 15 which makes plate 15^b negative with respect to its cathode, the charging current flowing from the center tap through winding 10^b, cathode 14^a to grid 14^c and plate 15^b.

If at the end of the described half cycle the voltage of the transformer winding reverses, the tube 14 tends to conduct current through the winding 10^b, while tube 13 cannot conduct any current on account of the reversal of the polarity at its main electrodes. However, grid 14^c being negative, no current can flow through tube 14 until the condenser 15 is discharged through coils 10^a and 10^b and resistance 18, whereupon tube 14 becomes conducting and energizes coil 10^b. This charges condenser 16 in the manner aforedescribed in connection with condenser 15, and during the next half cycle current flow through tube

13 is delayed in the same manner as has been described for tube 14.

By adjusting the resistances 17 and 18 the effective current passing through the coils 10^a and 10^b can be adjusted individually, thereby making it possible to separately adjust the energy delivered to the plunger of the hammer for the forward and return stroke.

It will be apparent that one of the windings of the hammer may be omitted and the plunger biased to one extreme position by a spring, while the remaining coil is arranged to periodically counteract the spring when its current is controlled in the manner described. In this case the winding which is omitted is replaced in both Figs. 1 and 2 by a suitable impedance, as will be obvious.

What I claim as new and desire to secure by Letters Patent is:

1. The combination with a reciprocating hammer or the like, having windings for operating the hammer in opposite directions, of means to alternately supply said windings with current, said means including a vapor discharge tube in series with each winding and having a grid, means to impress periodically and synchronously with said current a transient potential upon the respective grid to thereby prevent restarting of current through the respective winding after interruption thereof, and an energy storage discharge circuit associated with each grid and controlling the rate of discharge of said potential.

2. In a controller for a reciprocating hammer or the like, the combination with a winding of the hammer, of a unidirectional vapor discharge device in series with said winding, and having an anode and a grid, means to simultaneously impress transient potentials upon said anode and grid to stop the discharge current of the tube, and an energy storage discharge circuit associated with said grid and controlling the rate of discharge of the transient potential on the grid.

3. The combination with a reciprocating hammer or the like, having windings for operating the hammer in opposite directions, of means to alternately supply said windings with current, said means including a vapor discharge tube in series with each winding and having a grid, means to impress periodically and synchronously with said current a transient potential upon the respective grid to thereby prevent restarting of current through the respective winding after interruption thereof, and an individually adjustable energy storage discharge circuit associated with each grid and controlling the rate of discharge of said potential.

4. In a controller for a reciprocating hammer or the like, the combination with a winding of the hammer, of a direct current supply, a gaseous discharge tube in circuit with said winding and said supply and having an anode and a grid, means to control the frequency of the current in the tube, said means including means to simultaneously impress transient potentials upon said anode and grid to stop the flow of current through the tube, and an adjustable energy storage circuit which retards the discharge of the transient potential impressed upon the grid, for regulating the time interval during which the tube is non-conducting.

5. In a controller for a reciprocating hammer or the like, the combination with two windings of the hammer, of a direct current supply, a gaseous discharge tube in circuit with each one of said windings and said supply and having an anode and a grid, energy storage means associated with each tube and capable of producing simultaneous transient potentials on its anode and grid as a function of starting of current flow in the other tube, and adjustable discharge circuits connected to said grids for controlling the time intervals during which the grids maintain their respective tubes non-conducting.

6. In a controller for a reciprocating hammer or the like, the combination with two windings of the hammer, of a direct current supply, a gaseous discharge tube in circuit with each of said windings and said supply and having an anode and a grid, means to control the frequency of the current supplied to said windings, said means including means to alternately impress simultaneous transient potentials upon said anodes and grids to stop the discharge current of the respective tube and adjustable energy storage means for regulating the time intervals during which the grids maintain their respective tubes non-conducting.

7. In a controller for a reciprocating hammer or the like, the combination with a winding of the hammer, of an alternating current supply, a gaseous discharge tube in circuit with said winding and said supply and having a grid and means to impress in synchronism with said alternating current a transient potential upon said grid, including an adjustable energy storage discharge circuit which retards the discharge of said transient potential for regulating the moment of starting of the current flow through the tube during alternate half cycles.

8. In a controller for a reciprocating hammer or the like, the combination with two windings of the hammer, of an alternating current supply, a gaseous discharge tube in circuit with each of said windings and said supply, connected to pass current to one or the other of said windings during alternate half cycles of the alternating current and having a grid, adjustable energy storage discharge means associated with each tube and arranged to impress a transient potential upon its grid as a function of the starting of current flow in the other tube and to discharge said potential for regulating the moment of restarting of the current flow through the tube.

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