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ELECTROMAGNETICALLY OPERATED MECHANISM USING RESONANCE EFFECTS

Filed July 18, 1949

Fig. 1.

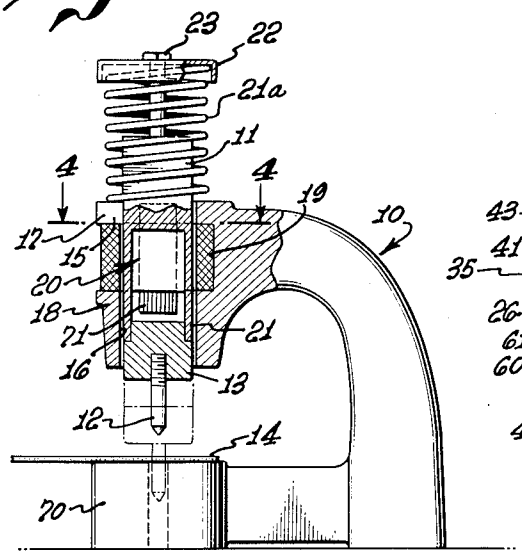


Fig. 2.

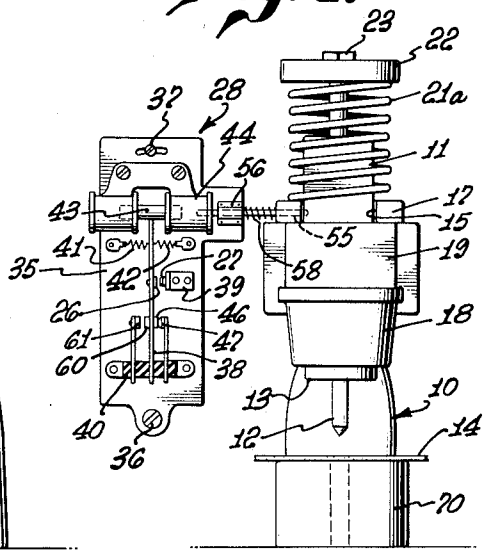


Fig. 3.

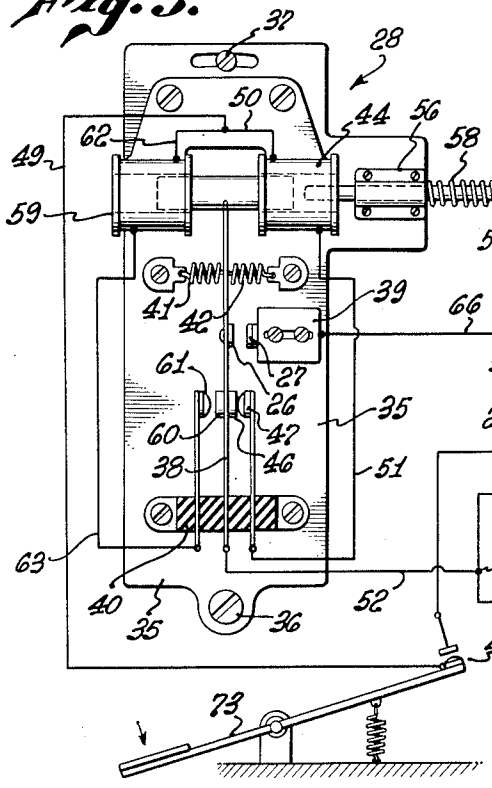
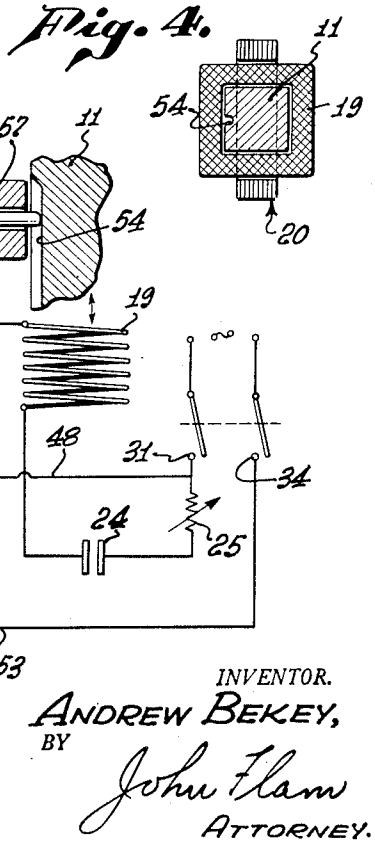


Fig. 4.



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ELECTROMAGNETICALLY OPERATED MECHANISM USING RESONANCE EFFECTS

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2 Claims. (Cl. 175—335)

1

This invention relates to electromagnetically operated mechanisms such as presses and the like wherein a plunger or armature carrying a tool is caused to operate on the work by an electromagnetic force.

In machinnes of this character control over the magnitudes of the current passing through the electromagnetic coil is desired. It is important that the current be small while the plunger is in inactive position for purposes of efficiency in operation and in design. It is, however, necessary to impart a sufficient momentum to the plunger so that it may satisfactorily do the work required.

It is one object of this invention to provide a circuit such that a very high current may act through a short time at an intermediate attracted position of the plunger or armature to produce the desired momentum and yet limit the current flowing at the extreme positions of the armature or plunger. In this manner, a small coil, consuming relatively little energy, may economically be used to achieve the desired results.

For this purpose, use is made of a series resonant circuit wherein resonance is achieved at a position intermediate the extremes of the path of the armature.

In machines of this character, it is important that the operation be limited to one cycle, such that safety with respect to the operator and the work is achieved. It is accordingly another object of this invention to insure against a recurrence of the operating cycle of the machine. For this purpose, use is made of a novel circuit controlled by the position of the plunger or armature itself, and also an electromagnet or the like which prevents the circuit energizing the machine from being closed, a manual operation of a simple nature being necessary to recondition the circuit for operation.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is an elevation, partly in section showing an electromagnetically operated mechanism;

2

Fig. 2 is an elevation showing the cooperative relation between the moving portions of the electromagnetically operated mechanism with respect to a circuit controller mechanism;

Fig. 3 is a diagrammatic representation of this invention including the cooperating electric circuits;

Fig. 4 is a sectional view taken along the plane 4—4 of Fig. 1.

A reciprocating machine such as a punch press 10 is shown, as in Figs. 1 and 2, provided with a plunger 11 movable with respect to the work support 70 forming a part of machine 10. A tool 12 and tool holder 13 are appropriately carried by the plunger 11. The tool 12 is adapted in this instance to perform a punching operation on the work 14, as shown by the dotted line position in Fig. 1.

The space in which the plunger 11 is adapted to move is defined by appropriate guiding bores 15 and 16 in the upper and lower bosses 17 and 18 projecting from the frame of the machine 10; the space is also defined by a coil 19 substantially aligned with said bores 15 and 16 and occupying a position between the bosses 17 and 18, as well as by a stationary magnetic frame 20 formed of laminations and surrounding the coil 19.

The magnetic frame 20 is generally a hollow rectangle formed of laminations, there being an opening in the top of the frame 20 to permit movement of plunger 11. The coil 19 is disposed within frame 20 and in alignment with the top opening. Thus the plunger forms a part of the magnetic circuit for the coil 19, the flux dividing through the ends of the frame 20. The plunger 11 has a hollow skirt portion 21 that is slotted at the bottom to permit relative movement with respect to the lower portion 71 of the frame 20. As shown most clearly in Fig. 4, the plunger 11 and coil 20 are generally of rectangular configuration.

In the position shown in Figs. 1 and 2, the coil 19 is not sufficiently energized to pull the plunger or armature 11 downwardly, and the plunger 11 is held in its upper or inactive position by the aid of a compression spring 21.

The plunger 11 for this purpose carries a retainer 22 of inverted cup form, as by the aid of a bolt 23 appropriately secured to the top of plunger 11. The spring 21 abuts the retainer 22 and also the upper boss 17 of the machine 10. The spring 21 will therefore bias the plunger 11 to the inactive position illustrated.

When the coil 19 is sufficiently energized to attract the plunger 11, the stationary core or frame

20 will reduce the effective reluctance of the magnetic circuit in which plunger 11 forms a part, as the magnetic circuit approaches closed position corresponding to the attracted position of the armature or plunger 11, indicated in dotted lines in Fig. 1.

As shown in Fig. 3, coil 19 is connected in series with a capacitor 24 and a variable resistor 25. Also in series with coil 19 is a pair of relatively movable contacts 26 and 27 forming a part of a circuit controller mechanism 28 to be hereinafter described.

In the inactive position of the circuit controller mechanism 28 as shown in Fig. 3, the contacts 26 and 27 are open, and thus the only path of current to the coil 19 is through a high impedance spark reducer consisting of a resistor 29 and a capacitor 30, the spark reducer being in parallel relationship with respect to the contacts 26 and 27.

The combined impedance of this paralleling circuit 29—30 of Fig. 3 is sufficiently high to prevent a large enough current from flowing in coil 19, such that plunger or armature 11 remains in the position shown in Figs. 1 and 2. The circuit may be traced as follows: terminal 31 of a source of alternating current, variable resistor 25, capacitor 24, coil 19, terminal 32, capacitor 30, resistor 29, lead 65, terminal 33, lead 53, to terminal 34 connected to the other side of the source.

Should it be desired to operate the mechanism, contacts 26 and 27 are closed (as will be hereinafter described) and the high impedance spark reducer 29—30 is thereby shunted. The circuit for operation of the plunger 11 may be traced as follows: terminal 31 of a source of alternating current, variable resistor 25, capacitor 24, coil 19, terminal 32, lead 66, contacts 26 and 27, lead 52, terminal 33, lead 53, and to terminal 34 connected to the other side of the source.

It is well known, that when an armature is in unattracted position, such as plunger 11 in Figs. 1 and 2, the inductance of the cooperating electromagnet coil, such as coil 19, is small. It necessarily follows that the inductive reactance due to this coil 19 is small, and thus the current is limited more directly by other circuit parameters.

The inductance will necessarily increase as the armature or plunger 11 moves into coil 19, and therefore the corresponding reactance increases.

It is desired that the current be small in the unattracted position of Figs. 1 and 2 in spite of a low value of inductance and inductive reactance of the coil 19. But it is furthermore desirable that large currents be obtained in order to impart sufficient momentum and energy to the moving plunger 11 when desired. For this purpose, capacitor 24 is inserted as heretofore described to limit the current passing through coil 19 when the plunger 11 is in unattracted position, corresponding to the instant when contacts 26 and 27 are moved into engagement. The capacitor 24 will provide a substantially constant capacitive reactance. The capacitor 24 is of such a magnitude that the capacitive reactance produced thereby is balanced by or balances the inductive reactance of the coil 19 at a particular intermediate position of the plunger 11. At this particular intermediate position of the plunger 11 (the inductance having increased as plunger 11 advanced) the series circuit becomes resonant, and as is well known, the current through coil 19 will be limited only by the variable resistor 25. In this manner a large current momentarily passes through coil 19, and the force acting on plunger 11 is of considerable magnitude. At this position of resonance the plunger 11 is greatly accelerated to achieve the desired momentum and energy necessary to operate on the work 14.

After the position of resonance has passed by continued movement of plunger 11, the force acting on plunger 11 may decrease, but the plunger 11 is still accelerated. When the tool 12 carried by the plunger 11 has encountered the work 14, the position of resonance has passed and the current becomes limited by the effective reactance (inductive) of the coil 19 and the capacitor 24.

The resistance of resistor 25 may be adjusted according to the amount of work required to be done.

The circuit controller mechanism 28 controlling contacts 26 and 27 includes a frame 35 suitably secured on a support, as by machine bolts 36 and 37 or the like. A resilient arm 38 insulatedly supported at its lower end on frame 35 carries contact 26, which contact is adapted to cooperate with contact 27. Contact 27 is carried by a support 39 which in turn is mounted on frame 35, but insulated therefrom.

Arm 38 is anchored at one end by the aid of insulation blocks 40 appropriately secured to frame 35.

Springs 41 and 42 are each anchored at one end on frame 35 and their free ends are secured to opposite sides of the resilient arm 38. These springs 41 and 42 thus oppose each other and tend to maintain arm 38 in the inactive position shown in Fig. 3 such that contacts 26 and 27 are out of engagement.

For moving arm 38 to close contacts 26 and 27 in order to initiate the operation of the machine 10 through energization of coil 19, a magnetic plunger 43 is mounted at the free end of arm 38. This plunger 43 is adapted to be attracted by an electromagnet coil 44.

In order to provide for the energization of electromagnet coil 44, a remote control switch 45, preferably operated by a pedal 73, is adapted to connect electromagnet coil 44 to a source of electrical energy. The circuit for electromagnet coil 44 includes a pair of relatively movable contacts 46 and 47. Contact 46 is carried by arm 38, and contact 47 is insulatedly mounted, similar to arm 38, on frame 35.

In the inactive position shown in Fig. 3, contacts 46 and 47 are in engagement so that operation of the remote control switch 45 may operate coil 44 to attract armature 43 against the spring forces of springs 41 and 42, causing contacts 26 and 27 to engage so that coil 19 may be appropriately energized to operate the plunger 11.

The circuit for electromagnet coil 44 may be traced as follows: terminal 31, lead 48, remote control switch 45, leads 49 and 50, coil 44, lead 51, contacts 47 and 46, arm 38, lead 52, terminal 33, lead 53, and terminal 34.

It is desired that the plunger 11 be limited to one cycle for each operation of pedal 73. While it may conceivably be possible that remote control switch 45 may be released promptly to interrupt energization of electromagnet coil 44, permitting springs 41 and 42 to return arm 38 to inactive position, it is apparent that this depends on quick coordinated action by the individual operator. For insuring against an unwanted repetition of the cycle, use is made of the motion of the plunger 11 itself in order to open contacts 46 and 47 as well as contacts 26 and 27 to interrupt current flow to the coil 19, and also to in-

sure against an energization of coil 44, regardless of the position of the remote control switch 45.

As is shown most clearly in Figs. 4 and 3, plunger 11 is provided with a cam surface 54 adapted to move a cam follower 55 when plunger 11 approaches the extreme attracted position. The cam follower 55 is guided for longitudinal movement by a cam follower guide 56 suitably mounted on frame 35. The cam follower 55 is further guided in a recess 57 provided in boss 17 of machine 10. One end of a light compression spring 58 abuts the cam follower guide 56 and at the other end is attached to the cam follower 55 to urge it into engagement with cam surface 54.

The cam follower 55 is adapted to contact armature 43 to move arm 38 to separate both contacts 26 and 27 and contacts 46 and 47. This is accomplished by the cam follower 55 being given an abrupt longitudinal movement by a steep rise in the cam surface 54, spring 58 being sufficiently light to permit the cam follower 55 to leave the cam surface 54. In this manner, energization of coil 19 is interrupted, and also the circuit for energization of electromagnet coil 44 is interrupted.

In order to insure against a subsequent undesired operation of electromagnet coil 44, should remote control switch 45 not be released as the plunger 11 is retracted by spring 21 (contacts 26 and 27 having been separated), an electromagnet coil 59 is adapted to attract armature 43 and insure against the return of arm 38 to close contacts 46 and 47.

As the cam follower 55 moves armature 43 to the left, contacts 60 and 61 are established. Contact 60 is carried by arm 38 and contact 61 is insulatedly supported in a manner similar to that of contact 47.

Should the pedal 73 still be depressed, maintaining switch 45 closed, the closing of contacts 60 and 61 by cam follower 55 establishes a circuit for electromagnet coil 59 as follows: terminal 31, lead 48, switch 45, lead 49, lead 62, coil 59, lead 63, contacts 61 and 60, arm 38, lead 52, terminal 33, lead 53, and terminal 34. Thus, the cam follower having established indirectly the circuit for electromagnet coil 59, if switch 45 is still closed, electromagnet coil 44 is prevented from being energized since contacts 46 and 47 are held apart by electromagnet coil 59. Thus there is no danger of a repeated cycle for plunger 11 as long as switch 45 is maintained closed.

Should the switch 45 thereafter be released, the excitation to electromagnet coil 59 will be interrupted, and springs 41 and 42 will return arm 38 to the inactive position of Fig. 3. In this position, electromagnet coil 44 may again be operated by closing remote control switch 45, and another cycle may be instituted.

It is thus necessary to release switch 45 before another cycle may be instituted.

The inventor claims:

1. In an electromagnetically operated mechanism having a armature or the like movable between attracted and unattracted position: electromagnet coil means adapted to attract said armature; means yieldingly urging said armature to a definite unattracted position a capacitance in series with said electromagnet coil means and having a reactance equalled by that of said electromagnet coil means when said armature is intermediate attracted and unattracted position; circuit means connecting said electromagnet coil means and said capacitance to a source of electrical energy; a circuit controller mechanism interposed in said circuit means; spring means biasing said circuit controller to open position; means closing said circuit controller mechanism including a remote control switch; means operated by said armature for opening said circuit controller; and means responsive to operation of said circuit controller opening means and dependent upon the continued closing of said remote control switch for preventing the closing of said circuit controller.

2. In an electromagnetically operated mechanism having an armature or the like movable between attracted and unattracted position: electromagnet coil means adapted to attract said armature; a capacitance in series with said electromagnet coil means and having a reactance equalled by that of said electromagnet coil means when said armature is intermediate attracted and unattracted position; circuit means connecting said electromagnet coil means and said capacitance to a source of electrical energy; a circuit controller mechanism interposed in said circuit, said circuit controller mechanism having a pair of relatively movable cooperating contacts; a movable arm carrying one of said relatively movable contacts; spring means engaging said arm for biasing the said arm to contact opening position; means moving said arm into contact closing position including an electromagnet, a circuit therfor and a remote control switch; a member operated by said armature when said armature moves to attracted position moving said arm to contact opening position; and means operated by said member dependent upon the continued closing of said remote control switch preventing the closing of said contacts.

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