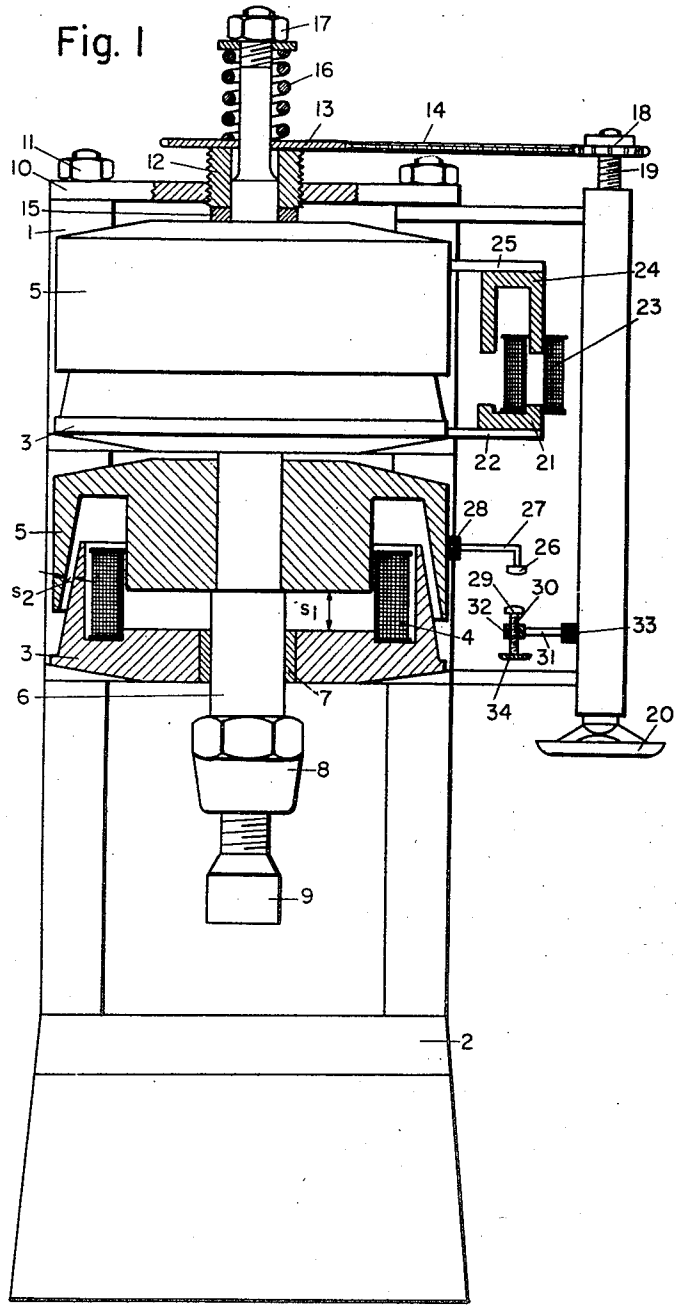
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ELECTROMAGNETIC PRESS

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Fig. 1



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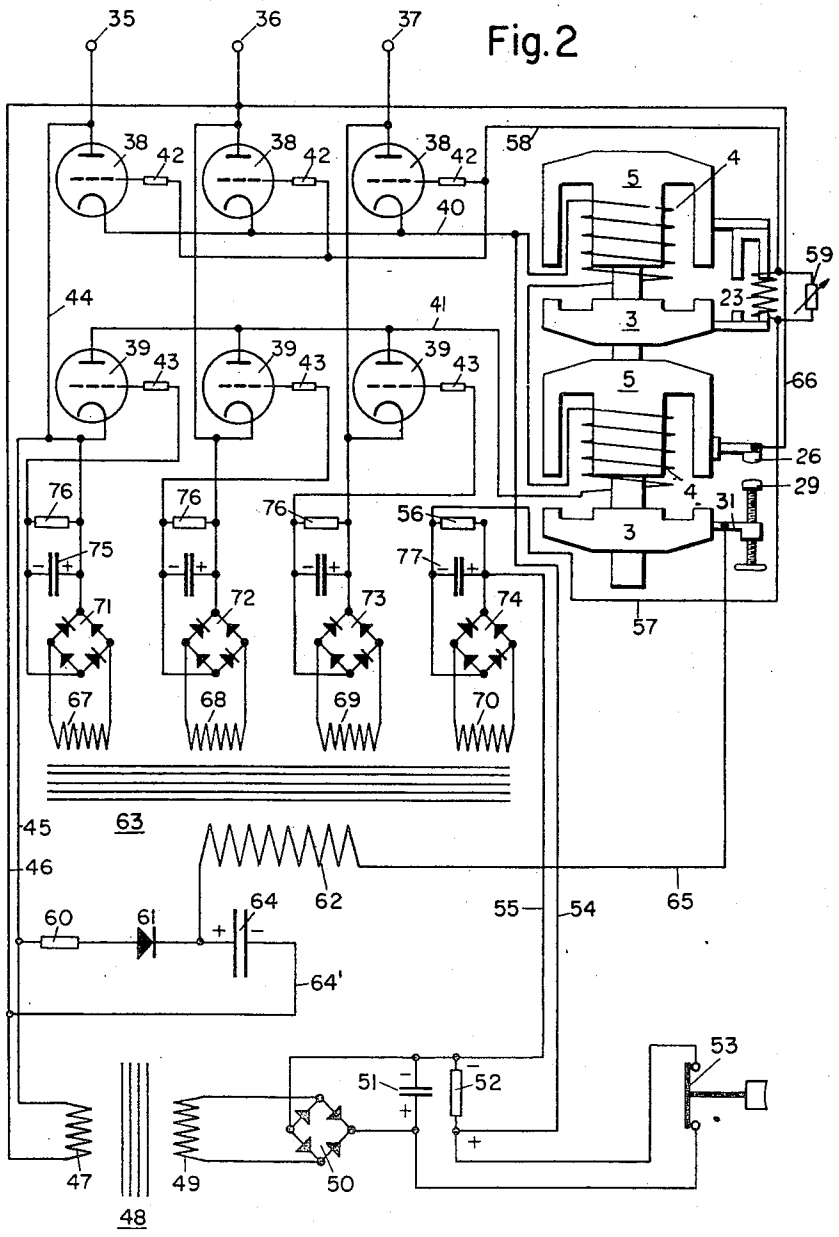
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Fig. 2



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ELECTROMAGNETIC PRESS

Rudolf Diener, Zurich, Switzerland, assignor to Elemag-Anstalt, Vaduz, Liechtenstein

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4 Claims. (Cl. 100—256)

The present invention relates to magnetic presses, and has the primary object of providing a press suitable for producing higher press forces than attainable hitherto.

It is another object of the invention to provide an electromagnetic press which works without detrimental and noisy impacts.

It is yet another object of the invention to provide an electromagnetic press the rate of operation and length of stroke of which is steplessly and accurately adjustable.

Other objects of the invention will become apparent later in this specification.

The know electromagnetic presses have been provided only with a single magnet coil and a single magnet armature, and are therefore suitable only for comparatively low press forces since the dimensions of the coil and of the armature, particularly the diameter thereof, could not be made as large as desired for practical reasons. The provision of several magnet coils and armatures was faced with the difficulty of making the armatures act in unison on the press punch without weakening the forces applicable by the individual coils.

With some of the aforesaid objects in view I provide an electromagnetic press comprising in combination: a stationary structure, several magnet coils fixedly arranged in the said structure, a number of magnetic armatures equal to that of the said magnet coils, a press punch, and a force transmitting member consisting of a non-magnetizable material connecting the said armatures with one another and with the said punch, the said armatures co-operating each with one of the said magnet coils and being longitudinally movable with respect thereto.

In contrast to the known electromagnetic presses, in which the exciter current of the magnet coil is switched on with the usual contact switches and which consequently work impact-like and cause great noise, I provide an electromagnetic press of the kind referred to comprising electronic control means controlling the exciter current of the said magnet coils. Such a press not only is capable of producing very high press forces, but works almost noiselessly and is steplessly adjustable both as regards the rate of operations and the length of stroke. Such a press is consequently particularly suitable for very accurate work, such as deep drawing, straightening, cold flowing, punching, stamping etc.

An embodiment of the invention is illustrated by way of example in the accompanying drawings, in which:

Fig. 1 shows the mechanical part of the press, partly in longitudinal section,

Fig. 2 shows the electric wiring diagram thereof.

On columns 1, rigidly connected to a work bench 2, two magnet coil cups 3 are attached, of which the lower one is shown in section, and the upper one in elevation. In the coil cups 3, coils 4 are embedded. The magnet armatures 5 are rigidly connected with one another by a presser stem 6. The presser stem 6 is vertically slidable in two bearings 7 provided in the coil cups 3. The press punch 9, which is adjustable in height by a screw thread,

can be clamped fast in the usual manner to the lower end of the stem 6 by means of a nut 8.

The presser stem 6 consists of substantially non-magnetizable material for example of a conventional iron-nickel alloy of low content in chromium. This alloy has a very high mechanical strength, but only a very low magnetic permeability. If the stem 6 were not made of a practically non-magnetizable material, the magnetic flux generated by the coil 4 would pass substantially through the said stem, and the mutually juxtaposed end faces of the coil cup 3 and armature 5, separated from one another by the variable air gap S_1, would exert only a very low force of attraction on one another. Only the attraction between the conical surfaces, separated by the air gap S_2, of the armature 5 and cup 3 would work out usefully. Since, however, the material of the presser stem 6 is non-magnetizable, the magnetic flux will pass mainly through the air gap S_1, so that by each of the two magnet coils 4 a high attraction force is applied to the corresponding armature 3, which forces are transmitted in unison through the presser stem 6 to the press punch 9.

A cover plate 10 is fixedly screwed to the columns 1 by means of nuts 11. An adjustment screw 12 provided with an external screw thread and screwed into the cover plate 10, can be turned by means of a sprocket wheel 13 for adjusting the upper limit of the stroke of the presser stem. The sprocket wheel 13 is connected through a roller chain 14 to a sprocket wheel 18, which is in turn connected by a spindle 19 to a hand wheel 20. A rubber buffer 15 prevents a hard impact upon a withdrawal movement of the stem. A return spring 16 is adjustable by means of a nut 17. A magnet core 21 is connected to the stationary upper coil cup 3 by means of a connecting piece 22. The magnet core 21 is provided with an induction coil 23. An armature 24 of permanently magnetised steel is fixedly connected to the upper magnet armature 5 by means of a connecting piece 25.

A contact 26 is mechanically attached to the lower magnet armature 5 by means of a resilient connecting piece 27 and of an insulator 28. A contact 29 is connected to a spindle 30, which can be adjusted screwwise in height in a nut 32 by means of a turning knob 34. The nut 32 is mechanically connected to a part of the machine frame by means of a connecting piece 31 and of an insulator 33.

For the electronic control of the exciter current in the magnet coils 4, the means illustrated in Fig. 2 are provided:

The terminals 35, 36, 37 of three-phase mains are connected to the anodes of three grid-controlled valves 38 and to the cathodes of three further grid-controlled valves 39. The cathodes of the valves 38 are connected to the anodes of the valves 39 through a conductor 40, the two magnet coils 4 arranged in series, and a conductor 41, so that the valves 38, 39 form a three-phase full-way rectifier, and the rectified current flows through the magnet coils 4, provided the valves 38, 39 are not blocked by bias voltages applied to their grids and negative with respect to their cathodes. Protective resistors 42 and 43, respectively, are arranged in series with the grids of the valves 38, 39 respectively.

To the input terminals 35 and 36 the primary coil 47 of a transformer 48 is connected through the lines 44, 45 and 46, the secondary coil 49 of which transformer is connected to a full-way rectifier 50. The rectifier 50 is connected at its output side to a condenser 51 across which a resistor 52 is shunted through a switch 53. The switch 53 is normally held in the closed position as shown by the bias of a spring (not shown), so that a voltage drop occurs across the resistor 52. The end marked + of the resistor 52 is connected by a line 54 and the line

50 to the cathodes of the valves 38. The end marked — of the resistor 52 is connected to the protective resistors 42 of the grids of the valves 38 through a line 55, a resistor 56, a line 57, the induction coil 23 and a line 58. As long as the switch 53 is closed, a negative bias voltage accordingly prevails on these grids relative to the corresponding cathodes, so that the passage of current through the valves 38 is blocked.

In order to energise the magnet coils 4 the switch 53, which is for example as a pedal switch, is opened, so that no more current flows through the resistor 52 and accordingly no voltage drop is set up across the same.

The magnet coils 4 are accordingly energised, and the coil cups 3 attract the armatures 5. By the movement of the armatures 5 produced thereby, the permanent magnet, armature 24 penetrates into the induction coil 23 which has a great many turns. By the increase of the magnetic flux passing through this coil 23 produced thereby, a voltage is generated which becomes effective between the cathodes and the grids of the valves 38 on the one hand via 58 and 42, and on the other hand via 57, 56, 55, 52, 54; this voltage is so directed, that it is negative on the grids, whereby the current passing through the valves 38 is reduced which involves a slowing-down of the movement of the armature 5 and accordingly of the press punch 9. In order to be able to influence the velocity of the movement of the press punch, which naturally depends also on the resistance of the work piece to be treated reacting on the press punch, the induction coil 23 has an adjustable resistor 59 shunted in parallel. When the value of the resistance of 59 is a maximum—eventually amounting to infinity with the resistor 59 completely switched off in the last regulating stage—the braking of the operative stroke of the press punch caused by the coil 23 is a maximum.

In order to terminate the downward movement of the press punch after the stroke desired, a negative bias voltage is applied to the grids of the valves 38 and 39. For this purpose a rectifier 61 is connected to the line 45 via a resistor 60, which rectifier is on the other hand connected to one end of the primary coil 62 of a transformer 63 and to a condenser 64. The condenser 64 is connected on its other side to the line 46 through a line 64', while the primary coil 62 is electrically connected through a line 65 to the contact 29, which is adjustable by means of the turning knob 34 and the holder 31 of which is for simplicity's sake shown in Fig. 2 as if directly attached to the coil cup 3. The contact 26 opposite the contact 29 is connected to the input terminal 36 through a line 66. The condenser 64 is charged in the circuit of 35, 44, 45, 60, 61, 64, 64', 46, 36. When the contact 26 touches the contact 29 upon downward movement of the press punch, the condenser 64 discharges itself in the circuit 35, 62, 65, 29, 26, 66, 46, 64', so that a current impulse is formed in the primary coil 62. The transformer 63 has four secondary coils 67, 68, 69 and 70, each of which is connected to a full-way rectifier 71, 72, 73 and 74, respectively. Each of the rectifiers 71—73 has its output connected to a condenser 75 and a resistor 76 shunted across the same, on which a voltage drop occurs when the said current impulse occurs in the primary coil 62. Each of the resistors 76 is connected on the one hand to the cathode, and on the other hand to the protective resistor 43 of the grid of one of the valves 39, namely in such a manner that when the aforesaid voltage drop occurs, the grid becomes negative with respect to the cathode, and accordingly blocks the passage of current.

The rectifier 74 has its output likewise connected to a condenser 77; the same is shunted across the resistor 56 mentioned hereinabove. The voltage drop occurring across the same causes the blocking of the three valves 38, namely in the circuit 40, 54, 52, 55, 56, 57, 23, 58, 42 starting from the cathodes of these valves; it should moreover be remarked that upon occurrence of the voltage drop across the resistor 56 there is no voltage drop across the resistor 52, since the switch 53 is open. It is accordingly clear that by adjusting the spacing between the contacts 26 and 29 the end of the working stroke of the press punch may be adjusted at will. This adjustment is very accurate in practice e.g. $\frac{2}{1000}$ of a millimetre.

For the retraction movement of the press punch 9 a spring 16 need not necessarily be provided, which automatically returns the press punch upward, as soon as the armatures 5 are no longer attracted by the coil cups 3. The retracting of the press punch could alternatively be effected electro-magnetically, hydraulically or pneumatically. Moreover it should be remarked that instead of the induction coil 23 and the permanent magnet 24 alternatively two condenser layers charged with a voltage may be moved relative to one another, in order to generate a current impulse which may be exploited for setting up a negative grid bias voltage.

The grid-controlled valves may be electronic valves or alternatively ion valves ("current gates").

While I have described herein and illustrated in the accompanying drawings what may be considered a typical and particularly useful embodiment of my said invention, I wish it to be understood that I do not limit myself to the details and dimensions described and illustrated; for obvious modifications will occur to a person skilled in the art.

What I claim as my invention and desire to secure by Letters Patent, is:

1. An electromagnetic press, comprising in combination: a stationary structure, a magnet coil fixedly arranged in said structure, at least one magnetic armature, a press punch, a force transmitting member connecting said armature and said press punch, said armature cooperating with said coil and being movable with respect to said coil, a plurality of grid-controlled valves connected to one another in the form of a rectifier and having an output connected to said coil and energizing the same when said valves are in a condition to pass electric current; and speed-responsive control means mechanically connected to said structure and to said armature, respectively, said speed-responsive control means being electrically connected to the grids of certain of said valves and generating a bias voltage for said grids, said voltage having a magnitude depending on the speed of movement of said armature.

2. An electromagnetic press, comprising in combination: a stationary structure, a magnet coil fixedly arranged in said structure, at least one magnetic armature, a press punch, a force transmitting member connecting said armature and said press punch, said armature cooperating with said coil and being movable with respect to said coil, said speed-responsive control means comprising a permanent magnet armature and an induction coil movable with respect to one another, the relative movement of said magnet armature and said induction coil generating a voltage in the induction coil, the last-named voltage being said bias voltage and being generated with such polarity as to reduce the magnitude of current passing through said valves.

3. An electromagnetic press according to claim 2, further comprising an adjustable resistor shunted across said induction coil.

4. An electromagnetic press, comprising in combination: a stationary structure, a magnet coil fixedly arranged in said structure, at least one magnetic armature, a press punch, a force transmitting member connecting said armature and said press punch, said armature cooperating with said coil and being movable with respect to said coil, a pair of spaced relatively movable contacts electrically insulated from and mechanically connected to said structure and said armature respectively, said contacts having means for adjusting the spacing therebetween,

said contacts being electrically operatively associated with said magnet coil for deenergizing said magnet coil when the contacts touch one another, a condenser, means for charging said condenser, a plurality of grid-controlled rectifier valves, and a transformer having a primary coil connected in series with said condenser and with said pair of contacts and having secondary coils operatively electrically associated with the grids of certain of said rectifier valves, said condenser discharging itself through said primary coil when said contacts touch one another and inducing thereby in said secondary coils voltages producing negative grid bias voltages in said certain rectifier valves.

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