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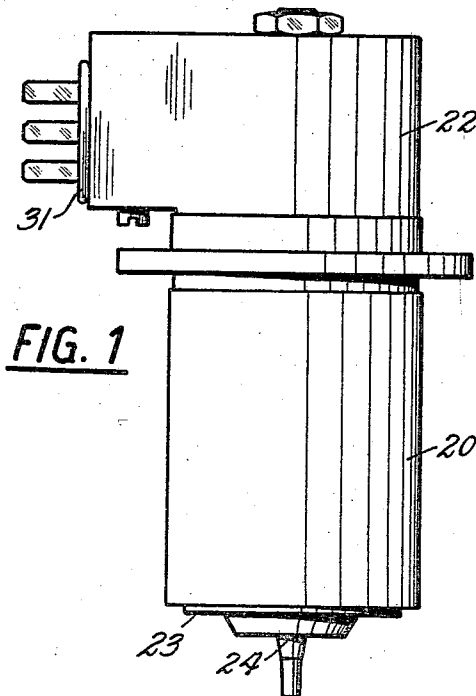
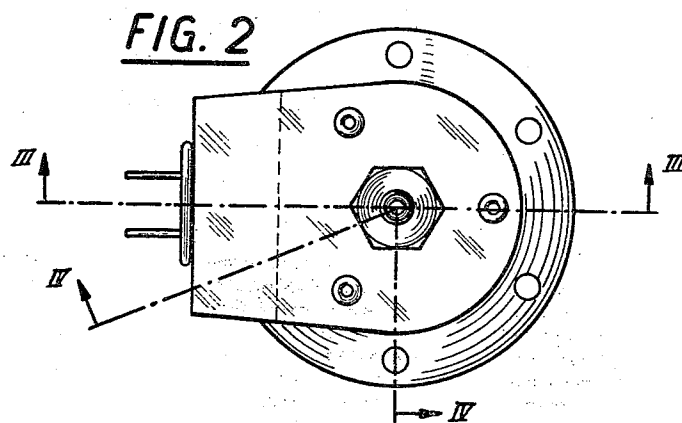
A. MIEVILLE

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MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 1



Oct. 1, 1963

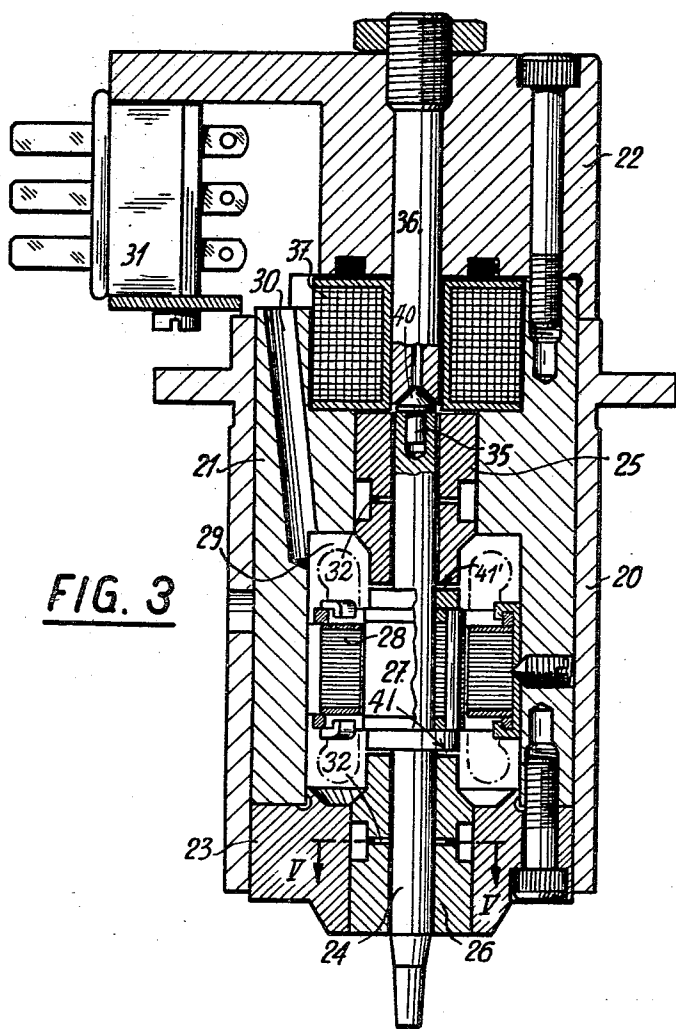
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MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

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Oct. 1, 1963

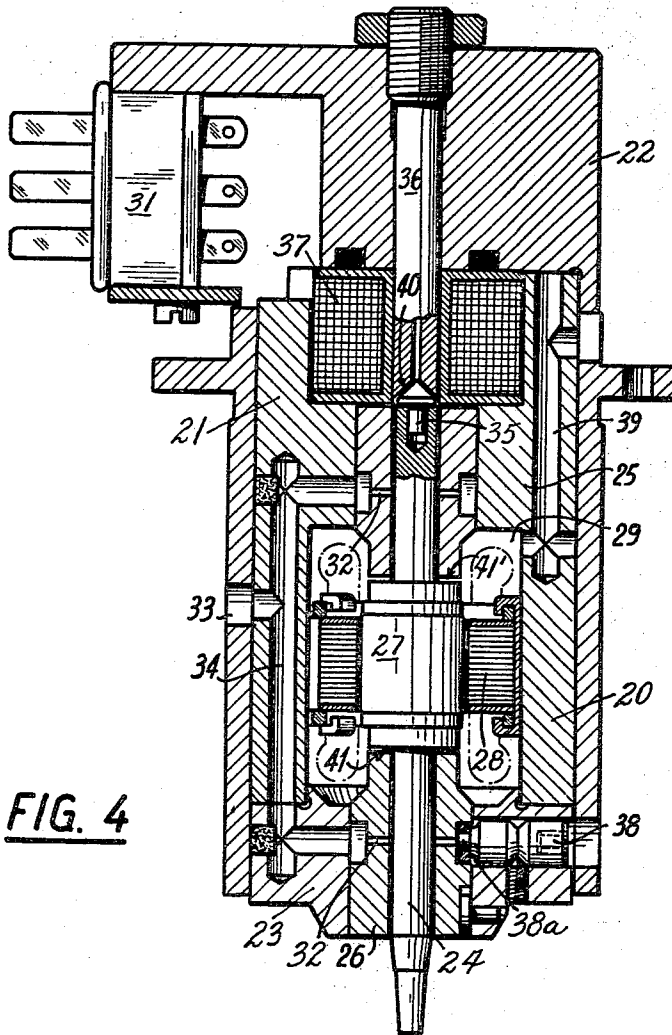
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3,105,482

MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 3



Oct. 1, 1963

A. MIEVILLE

3,105,482

MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 4

FIG. 5

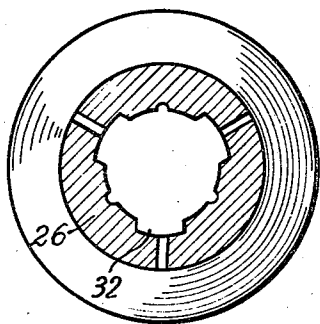


FIG. 8

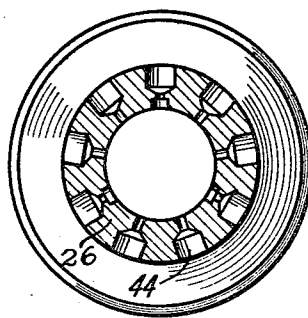
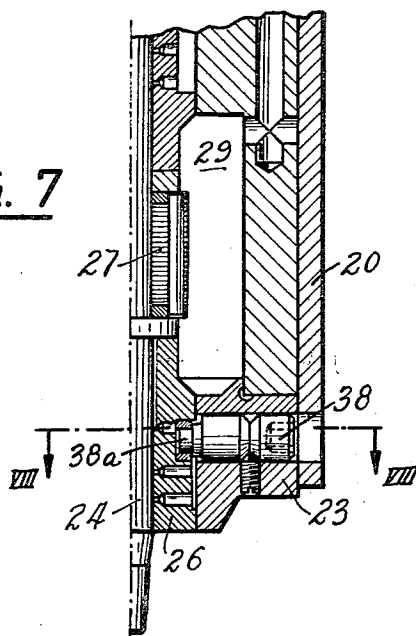


FIG. 7



Oct. 1, 1963

A. MIEVILLE

3,105,482

MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 5

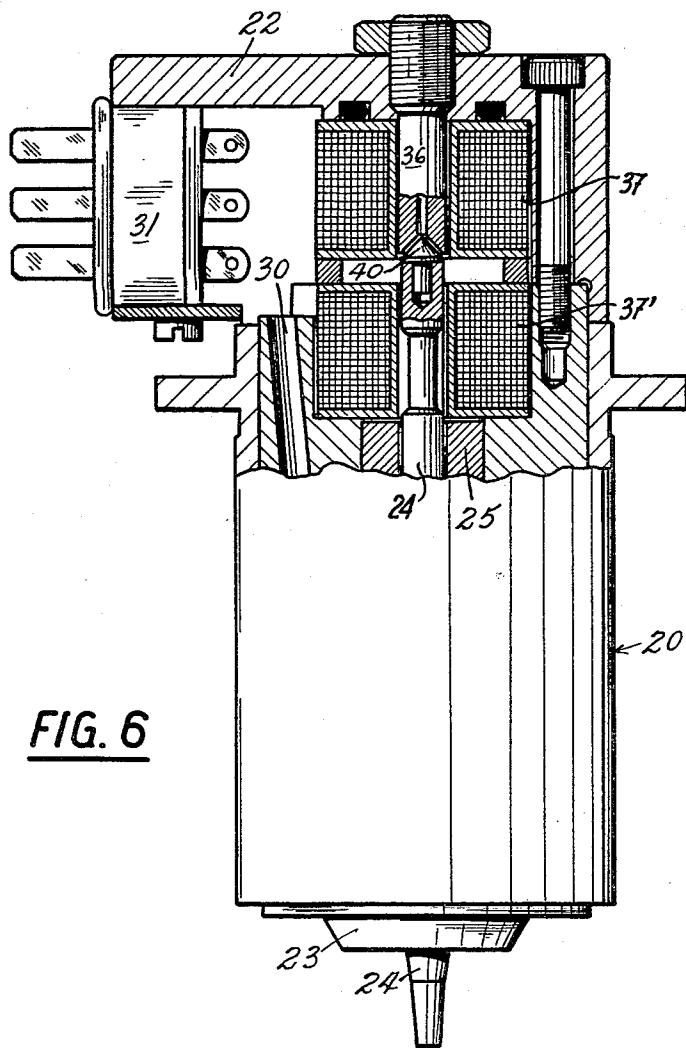


FIG. 6

Oct. 1, 1963

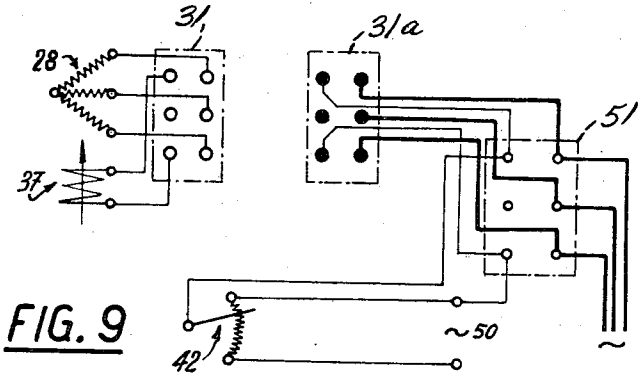
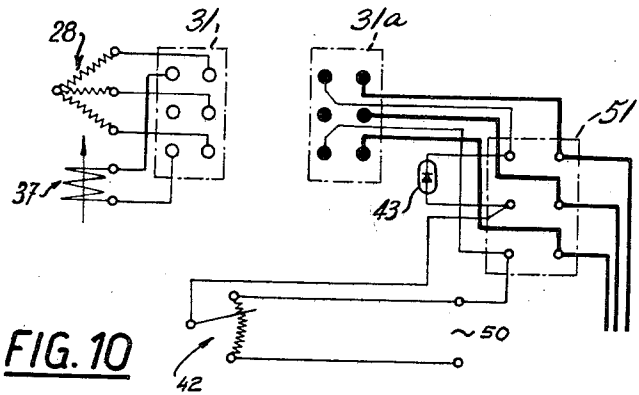
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3,105,482

MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 6



Oct. 1, 1963

A. MIEVILLE

3,105,482

MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 7

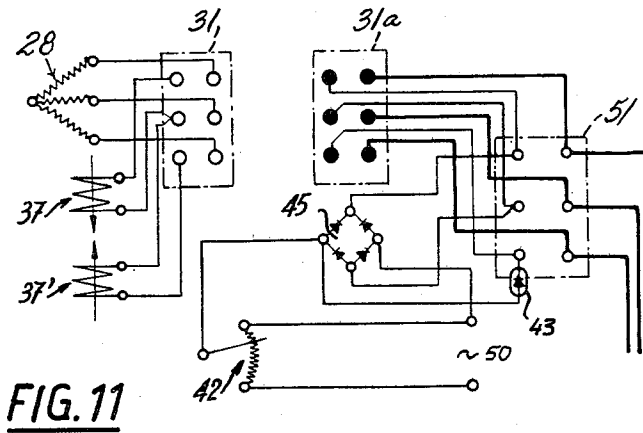


FIG. 11

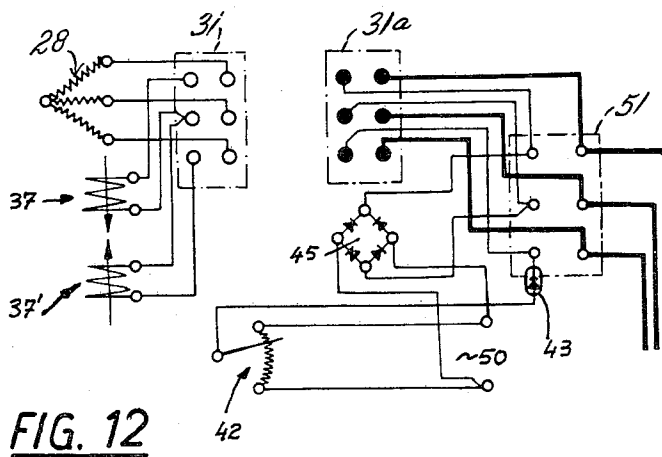


FIG. 12

Oct. 1, 1963

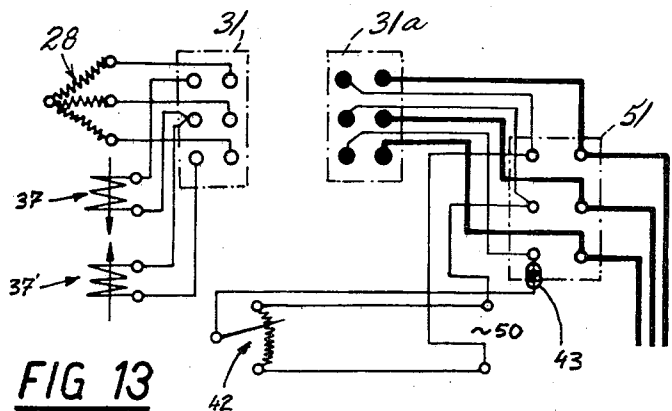
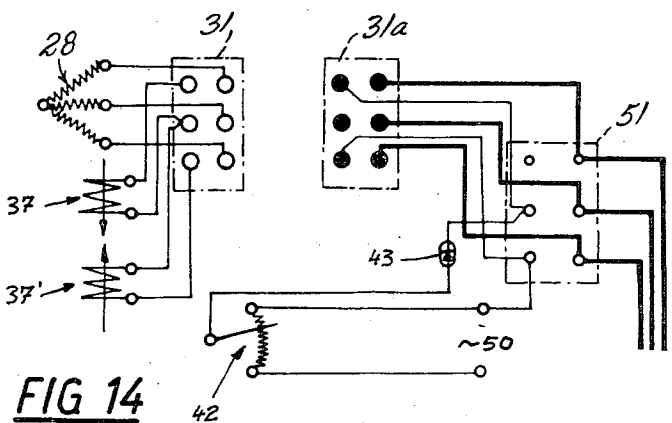
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MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 8



Oct. 1, 1963

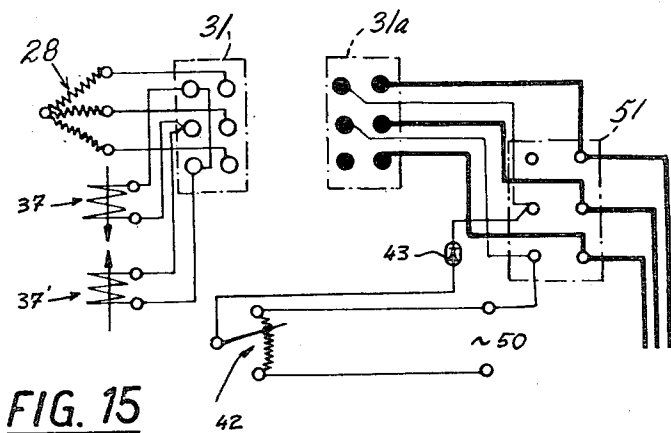
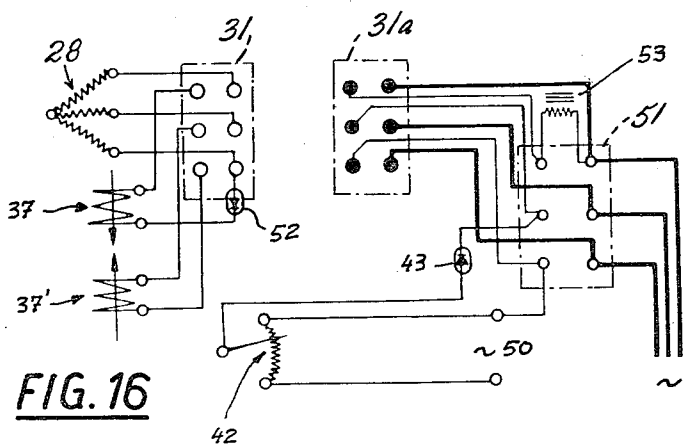
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3,105,482

MACHINE FOR DRILLING HOLES IN HARD MATERIALS

Filed Sept. 26, 1961

9 Sheets-Sheet 9



1

3,105,482

MACHINE FOR DRILLING HOLES IN
HARD MATERIALS

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3 Claims. (Cl. 125—30)

The present invention relates to a machine for making holes in hard materials, more particularly hard metals, ceramic materials, industrial stones, stones for dies, or stones for timepieces. This machine comprises a drill-supporting spindle subjected to the action of electromagnetic means which impart to the spindle a vibratory axial movement superimposed on the rotary movement of the spindle.

The machine according to this invention is characterised in that the spindle rotates in bearings with air bushes.

Embodiments of the invention chosen by way of example are illustrated in the accompanying drawings, in which:

FIGURES 1 and 2 are respectively an elevation and a plan view of a first embodiment;

FIGURES 3 and 4 are views in section on lines III—III and IV—IV of FIGURE 2;

FIGURE 5 is a view in cross-section, at the level of line V—V of FIGURE 3,

FIGURE 6 is a view in elevation, and partly in section, of a second embodiment;

FIGURE 7 is a view, partly in section, corresponding to FIGURE 4,

FIGURE 8 is a view in section on line VIII—VIII of FIGURE 7 (corresponding to FIGURE 5 of the first embodiment),

FIGURE 9 is a diagram of the electrical system of the first embodiment,

FIGURE 10 is a modification of this circuit,

FIGURE 11 is the electrical system of the second embodiment, and

FIGURES 12 to 16 are modifications of the electrical system of the second embodiment.

The first embodiment, illustrated in FIGURES 1 to 5 and 9, comprises a casing in the form of a cover 20, and a cylindrical body 21 located within this cover and closed at both ends by two caps 22 and 23. The drill-supporting spindle 24 rotates in two air-bush bearings 25 and 26 mounted respectively in the body 21 and in the lower cap 23. In its central portion the spindle 24 carries a rotor 27 of a three-phase high-frequency motor of which the stator 28 is accommodated in an annular chamber 29 of the body 21. A channel 30 is provided through which wires, not shown, lead to the stator, and to a six-pole connector 31 to which these wires are also connected.

The motor enables the spindle to be rotated at speeds of the order of 60,000 to 120,000 revolutions per minute.

The bearings are of the kind having chambers 32 (FIGURE 5) and are supplied with compressed air through an opening 33 and a duct 34 leading to the centers of the two bearings.

At the top end of the spindle 24 is disposed a conical nipple 35 engaging in a recess of corresponding shape in a tubular member 36 screwed into the cap 22. This member constitutes the core of an electromagnet of which the winding 37 is accommodated in the upper part of the body 21.

The distance of axial movement of the spindle 24 is limited at the bottom by the bearing 26 and at the top by the bearing 25. This distance can be accurately adjusted by axially displacing the bearing 26 by means of an eccentric device 38.

2

The inner cylindrical tip 38a of device 38 is slightly eccentric with its axis of symmetry displaced in relation to the axis of rotation to the axis of rotation of device 38; therefore, when device 38 is turned, the bearing 26 is shifted slightly upwards or downwards, as required, in the axial direction of spindle 24. Three such eccentric devices 38 are used and are disposed at an angular distance of 120°, to ensure accurate adjustment of bearing 26 on three peripheral points of application.

The coil 37 is energized with a single-phase alternating current taken from a network to which current is supplied by an alternator; in the system illustrated in FIGURE 9. The coil 37 is supplied with current through the connector 31 to which a plug 31a is connected and a potentiometer 42, in such a manner that during each half-wave the spindle 24 is lifted against the action of its own weight and then falls back under the action of its weight.

The amplitude of this vibratory axial movement is related to the weight of the spindle and the maximum strength of the magnetic field. This amplitude is limited by the possible distance of axial movement of the spindle between the bearings 25 and 26. This amplitude may be adjusted by variably setting the potentiometer 42, and by displacing the core 36; this displacement changes the air gap and the air throttling action at 40.

Some of the air driven through the bearings passes through gaps 41 and 41' and escapes through a duct 39 (FIGURE 4), some of this air passes out through the bottom part of the bearing 26, and the rest passes out through the member 36. Some of this air thus passes through the gaps 41 and 41' which form two air cushions that prevent the spindle from coming into contact with the members which limit the axial movement of the spindle.

Consequently, the spindle rotates and vibrates while suspended in air, and this results in minimum wear and very silent operation.

In the modification of the electrical system shown in FIGURE 10, a diode 43 is provided in the circuit through which current is supplied to the coil 37; in this way, every other half-wave is suppressed and the frequency of the vibratory movement is halved.

The second embodiment, illustrated in FIGURES 6, 7, 8 and 11, differs from the first embodiment in that on the one hand the electromagnet has two windings 37 and 37', and on the other the bearings 25 and 26 are provided with holes 44 (FIGURE 8).

In the second embodiment, the end of the spindle is located between the two windings 37 and 37' in such a manner as to be alternately attracted upwards and repelled downwards.

The winding 37 is excited by current from the network, rectified by a full-wave rectifier 45. The strength of this current can be regulated by means of a potentiometer 42. This strength, and the axial position of the member 36, are made such that the spindle maintains itself in its upper position, against the action of its weight, when the winding 37 is excited.

The vibratory movement is brought about by the winding 37' through which current from a source 50 passes; every other half-wave of this current is suppressed by the diode 43. This current produces a periodic field opposing the field of the winding 37, which causes magnetic repulsion between the member 35 and the core 36 and periodical descent of the spindle. The amplitude of the current passing through the winding 37' and also the strength of the current passing through the winding 37, are regulated by means of the potentiometer 42.

The only difference between this second embodiment and the modification thereof illustrated in FIGURE 12, is that the action of the winding 37 can be regulated only

by means of the member 36, whereas the action of the winding 37' can be changed by means of the potentiometer 42.

In the modification illustrated in FIGURE 13, the winding 37 is connected directly to the source 50. An alternating current passes through this winding and creates a field that exerts a periodic upwardly directed action on the spindle. The maximum strength of this field can be adjusted by changing the axial position of the member 36. Actually this field is so adjusted that in the absence of current in the winding 37' the spindle is raised intermittently, at the frequency of the current. The winding 37' is energized with current from the source 50 through the diode 43 which suppresses one half-wave in every two. The strength of this current can be adjusted by means of the potentiometer 42. During each period the spindle is successively subjected to a repelling action (when both windings are excited) which displaces the spindle downwards, and to an upwardly directed action (when only the winding 37 is excited).

In the modification illustrated in FIGURE 14, the source 50 supplies current to the windings 37 and 37' in series, and these windings create fields that oppose one another. Every other half-wave is suppressed by the diode 43, and the current can be adjusted by means of the potentiometer 42. As a result, the spindle is subjected to an intermittent downwardly directed action. The spindle is returned to an intermediate position by the resilient cushions formed by the air escaping through the gaps 40 and 41. This position can be adjusted by axial displacement of the member 36.

In the modification illustrated in FIGURE 15, the source 50 supplies current to the two windings in parallel. The manner of operation is the same as described with reference to FIGURE 14.

Lastly, in the modification illustrated in FIGURE 16 the winding 37 is connected between two phases of the high-frequency three-phase system supplying current to the stator coils 28. This current is rectified by a diode 52 and stabilised by an inductance 53. In the absence of current in the winding 37', the current through the winding 37 produces a practically constant field which keeps the spindle in its upper position. This action may be adjusted by axial displacement of the member 36. The winding is energized with current by the source 50, through the diode 43 which suppresses the negative half-waves. The positive half-waves produce a repelling action urging the spindle downwards. This action can be adjusted by means of the potentiometer 42.

In each embodiment of the invention the drilling machine is connected to the source 50 through a panel 51 from which the plug 31a is connected to the drilling machine.

What is claimed is:

1. In a drilling machine, the combination of a drill-supporting spindle, an electric motor including a rotor rigid with the spindle and a stator surrounding the rotor, tubular members surrounding with a slight clearance the

spindle on each side of the rotor and at a small distance from the corresponding terminal surface of the rotor to form axial abutments for said rotor, electromagnetic means to impart to the spindle and rotor an axial reciprocating vibratory movement the amplitude of which is defined by abutment of the rotor against the two tubular members in alternation, means feeding compressed air into the clearances between the spindle and the tubular members to form air bearings for said spindle, said air escaping at least partly between the terminal surfaces of the rotor and the corresponding tubular members.

2. In a drilling machine, the combination of a drill-supporting spindle, an electric motor including a rotor rigid with the spindle and a stator surrounding the rotor, a tubular member surrounding with a slight clearance the spindle on each side of the rotor and at a small distance from the corresponding terminal surface of the latter to form axial abutments for said rotor, electromagnetic means adapted to impart to the spindle and rotor an axial reciprocating movement the amplitude of which is defined by abutment of the rotor against the two tubular members in alternation, means feeding compressed air into the clearances between the spindle and the tubular members to form air bearings for said spindle, said air escaping at least partly between the terminal surfaces of the rotor and the corresponding tubular members, and hand-operable means controlling the axial position said one tubular member thereby to adjust the amplitude of reciprocation of the spindle.

3. In a drilling machine, the combination of a vertical drill-supporting spindle, an electric motor including a rotor rigid with the spindle and a stator surrounding the rotor, a tubular member surrounding with a slight clearance the spindle on each side of the rotor, two superposed electromagnetic windings coaxial with the spindle and disposed above the rotor, a core for the upper winding extending in vertical alignment with the spindle at an adjustable height above the spindle, a source of alternating current, a full-wave rectifier connected between said supply and the upper winding, a half-wave rectifier connected between said supply and the lower winding to produce a periodical repulsion of the spindle downwardly against the upwardly directed attraction exerted permanently by the upper winding, a potentiometer connected between said half-wave rectifier and the lower winding, and means feeding compressed air into the clearances between the spindle and the tubular members to form air bearings for said spindle.

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