

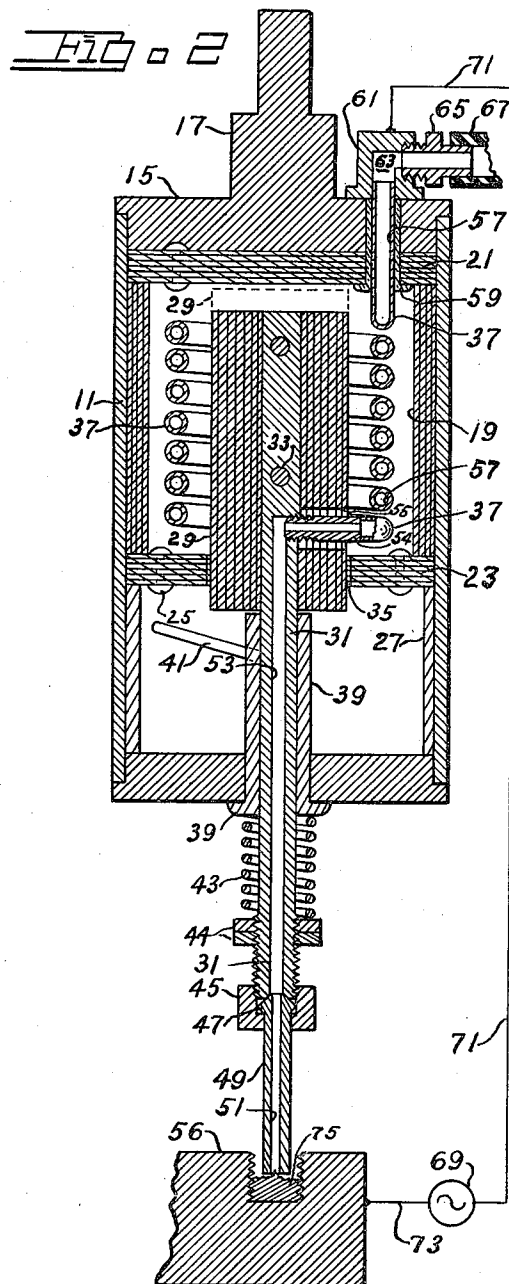
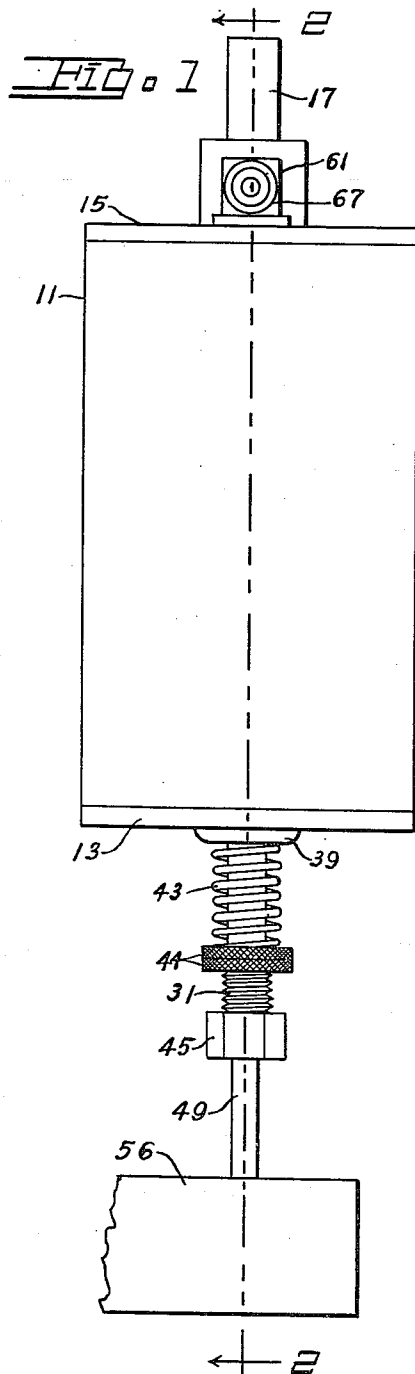
Aug. 21, 1945.

H. V. HARDING

2,383,383

ELECTROMAGNETIC VIBRATORY METALWORKING APPARATUS

Filed Oct. 13, 1943



INVENTOR  
HENRY V. HARDING

BY *J. D. Hicks*  
HIS ATTORNEY

## UNITED STATES PATENT OFFICE

2,383,383

ELECTROMAGNETIC VIBRATORY METAL-  
WORKING APPARATUSHenry V. Harding, Royal Oak, Mich., assignor to  
Elox Corporation, a corporation of Michigan

Application October 13, 1943, Serial No. 506,118

14 Claims. (Cl. 219—15)

The invention pertains to apparatus for disintegrating or removing metallic materials, and more particularly to a vibratory electromagnetic apparatus therefor.

It is an object of the invention to provide improved apparatus for effectively and conveniently disintegrating and removing metallic materials as in opening plugged holes, forming new holes, piercing and like operations.

It is also an object of the invention to provide improved electromagnetic apparatus for disintegrating or removing metals by an electrical current and a stream of fluid passing through a winding and an electrode in series relation.

The invention itself, however, both as to its organization and its mode of operation together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments, when read in conjunction with the accompanying drawing, in which:

Fig. 1 is a side elevational view showing an embodiment of the vibratory electromagnetic apparatus for disintegrating or removing metals; and

Fig. 2 is a sectional view on line 2—2 in Fig. 1. Referring more specifically to Figs. 1 and 2 of the drawing, the metal disintegrating apparatus comprises an enclosing and supporting casing 11, which may be a substantially cylindrical shell closed by a top end wall 15 and a bottom end wall 13 secured therein, as by cement or screws. The casing shell 11 and the end walls are preferably made of any suitable plastic composition material which is non-magnetic and electrically insulating, as well as water-proof. In assembly, the end walls 13 and 15 are secured into the ends of the casing shell as by cement, or screws, to form an enclosure. A stub 17 is provided rising axially from the center of the top wall 15 so that the device may be conveniently inserted and supported in any adjustable support, such as a drill press chuck.

Enclosed within the casing 11 is a field structure for providing low reluctance paths for magnetic flux, which may comprise cylindrical side walls 19 formed by winding a ribbon of thin ferro-magnetic sheet metal up on itself to provide a low loss laminated structure. End field discs 21 and 23 are also provided for closing the ends of the field structure at the top and bottom respectively. The end field discs are also preferably formed of thin discs of sheet ferro-magnetic material, stacked together and secured, as by rivets 25. The axial length of the cylindrical field mem-

ber 19 is less than the space within the casing 11 and a tubular spacer 27 is enclosed in order to hold the field members firmly in place and snugly together in the casing.

Disposed axially within the space is an armature 29, which may be formed by winding a ribbon of thin ferro-magnetic sheet metal upon the upper end of an extension 31 whereupon it is secured, as by rivets 33 passing through the upper end. In this manner a laminated low loss armature is formed and it is made of a suitable length to pass through a central aperture 35 in the lower field disc with its upper end suitably spaced from the upper field disc 21 to be effectively lifted when electrical current flows through a conductor 37 of a winding which may be wound helically and disposed concentrically around the armature in the space between the cylindrical field wall 19 and the armature. The armature extension 31 passes slidably through a bushing 39 in the center of the bottom end wall 13 of the casing 11 and it may be lubricated through a tube 41 extending out through the side wall of the outer casing 11. The bushing 39 may be selected of a suitable length so that its upper end serves also to limit the downward movement of the armature and it is of a suitably hard metal to minimize wear.

If it is desired to move the armature downwardly more rapidly than gravity would cause it, this is accomplished by a compression spring 43 disposed concentrically on the outwardly projecting end of the armature extension rod 31 below the bottom end 13 of the casing where the lower end of the spring reacts upon a pair of lock-nuts 44. The locknuts 44 are knurled, or suitably conformed, to facilitate adjustment for adjusting the tension of the spring and predetermining the frequency of operation of the device.

The lower end of the extension is externally threaded for receiving a chuck collar 45 whereby the enlarged head 47 of an electrode rod 49 may be clamped snugly against the end of the extension 31. The electrode 49 is hollow, having an aperture 51 extending therethrough from end-to-end, for flowing a fluid coolant or oxidizing medium therethrough to the point. The head 47 of the electrode is suitably conformed, as by having oppositely disposed conical surfaces, so that it is accurately centered and the aperture 51 is aligned and connected with an aperture 53 in the extension, when the chuck collar 45 is turned up on the extension. The extension 31 is of a non-magnetic metal, preferably, and the electrode 49

is of copper or some other soft non-ferrous metal.

The aperture 53 in the extension 31 extends up to a point adjacent the lower end of the winding conductor 37 where it opens out through the side and receives a threaded nipple or fixture 54 passing out through an opening 55 in the armature laminations. The lower end of the conductor 37 is connected to the outer end of the nipple 54, as by brazing, thus providing continuous electrical conductive connection from the electromagnetic winding down through the armature extension 31, thence through the electrode 49 and a piece of metal 56 to be worked. Also a fluid flow circuit is established from the upper end of the aperture 53 in the extension, through the nipple 54, and thence through an aperture 57 which extends throughout the conductor 37, which is a hollow or tubular member. The other, or upper, end of the conductor 37 passes from the upper end of the casing through an insulating bushing 59 and is secured snugly in a connection block 61, as by a press fit or threading therein. An aperture 63 leads through the connection block from the aperture 57 in the conductor and is threaded to receive one end of a hose nipple 65. By fitting a hose 67 upon the nose nipple connection is conveniently made with any suitable source of coolant or oxidizing fluid to be passed out of the point of the electrode and through the electromagnetic winding, simultaneously with the passage of electric current therethrough.

In operation, any suitable source of electrical current 69, which may be the secondary winding of a welding transformer, has its terminals electrically connected to the connection block 61 on top of the casing and to the work piece 56, as by conductors 71 and 73. The conductors 71 and 73 are connected in any convenient manner as by brazing, spring clips (not shown) or the like.

The point of the electrode 49 engages the work and the winding conductor 37 is energized from the electrical source 69. This causes the armature 29 to be drawn up, as indicated by dotted lines, compressing the spring 43 and pulling the electrode away from the metal piece 56. The electromagnetic winding then becomes deenergized permitting the spring to again press the electrode down engaging the work piece. The winding is then again energized and this cycle of operation is repeated rapidly so the armature 29, the extension 31 and the electrode 49 vibrate at a rate determined by the weight of the parts and the tension adjustment of the spring 43. During this operation, the coolant fluid flows continuously through the conductor 37 of the winding thence in series relation through the electrode 49. In this manner the parts are directly cooled permitting heavy current energization for rapid metal disintegration by means of a small or compact apparatus, and eliminating the necessity for separate or external connections to the electrode. The turns of the conductor 37 in the winding being relatively flexible permits the lower end of the conductor to vibrate freely with the electrode and the armature.

Also the same stream of coolant fluid passing through the winding and thence in series through the electrode and from the point serves to effectively and rapidly disintegrate or remove the metal from work piece 56. Hot spots being formed in the work by the heavy electrical current from the point of the electrode are then

suddenly chilled by the coolant from the point of the electrode. This causes contraction of the metal in the hot spots with consequent scaling and chipping off. Also water in the presence of the electric arcs breaks down to provide H and O<sub>2</sub>. And the latter in the presence of the arcs and high temperatures provided causes rapid oxidation of the metal. The latter may be relatively more effective when working softer metals and the former effect of chipping off, may be more effective when working hardened metals as in removing broken taps and the like. At times both effects are present and effective. The excess flow of coolant provided flushes away the disintegrated metals, and the result, irrespective of the theory by which it may be explained, is that metal is rapidly and conveniently removed either to open a plugged hole or to form a new hole.

I do not wish to be restricted to the specific structural details and arrangement of parts as herein set forth, as it will be apparent that various modifications may be made without departing from the spirit and scope of my invention.

I claim:

1. Metal working apparatus comprising, an electromagnetic winding, said winding being formed of tubular metallic conductor so that coolant fluid and electric current may flow through the winding simultaneously, an armature disposed movably adjacent said winding for movement thereby, an extension connected to and projecting from said armature for moving an electrode, a fluid flow passage in said extension, and one end of the conductor of said winding being connected into said extension for movement therewith and for conducting electric current and coolant fluid therethrough.

2. The combination in metal working apparatus of, an electromagnetic winding, said winding being formed of tubular metallic conductor so that coolant fluid and electric current may flow through the winding simultaneously, an armature disposed for movement by the electromagnetic field set up by passage of electric current in said winding, extension means projecting from said armature for operatively moving an electrode, a fluid flow passage in said extension means, one end of said winding conductor being connected into said extension means for movement therewith and for transmitting electric current and coolant fluid therethrough, field structure disposed adjacent the winding and armature for reducing the reluctance of the magnetic flux paths, support structure for mounting said winding and field structure and guiding and limiting the movements of the armature, and the other end of the winding conductor being mounted on said support structure for convenient connection with electrical energy and coolant fluid.

3. In combination in metal working apparatus for disintegrating or removing metallic materials, a substantially helical solenoid electromagnetic winding, said winding being formed by a tubular metallic conductor for conducting a coolant fluid to directly absorb and carry away heat generated by electrical losses while the winding is energized by passage of electric current therethrough, an armature disposed movably for movement axially within said winding, a projecting extension connected to and projecting from said armature for moving an electrode, a fluid flow passage in said extension, one end of the conductor of said winding being connected into said extension for move-

ment therewith and for conducting electric current and coolant fluid therethrough.

4. Metal disintegrating or removing apparatus comprising a substantially helical solenoid electromagnetic winding, said winding being formed by a tubular metallic conductor for conducting a coolant fluid to directly absorb and carry away heat generated by electrical losses while the winding is energized by passage of electric current therethrough, an armature disposed movably for movement axially within said winding, a projecting extension connected to and projecting from said armature for moving an electrode, a fluid flow passage in said extension, one end of the conductor of said winding being connected into said extension for movement therewith and for conducting electric current and coolant fluid therethrough, field structure disposed adjacent the winding and armature for reducing the reluctance of the magnetic flux paths, support structure for mounting said winding and field structure and for guiding and limiting the movements of the armature, and the other end of the winding conductor being mounted on said support structure for convenient connection with a source of electrical energy and a source of coolant fluid.

5. In metal working apparatus the combination in accordance with claim 2 and further characterized by said fluid flow passage extending axially in said extension means, and electrode holder means on said extension means for conveniently receiving or releasing a hollow electrode and connecting the hollow electrode for the transmission of electric current and coolant fluid therethrough.

6. Metal disintegrating or removing apparatus comprising the combination in accordance with claim 4 and further characterized by said extension having an electrode holder thereon for conveniently receiving and holding or releasing a hollow electrode and for connecting the hollow electrode for the transmission of electric current and coolant fluid therethrough.

7. Metal working apparatus comprising an electromagnetic winding, said winding including a tubular metallic conductor so that coolant fluid and electric current may flow through the winding simultaneously, an armature structure disposed movably adjacent said winding for movement thereby and having an extension thereon adapted to support a hollow electrode, a fluid flow passage in said extension, and electric and fluid flow conducting means connected to one end of the conductor and connected to said armature structure for movement therewith and communicating with the passage in said extension for conducting coolant fluid therethrough and electrically connecting said conductor and extension.

8. Metal working apparatus comprising an electromagnetic winding, said winding including a tubular metallic conductor in the form of a coil so that coolant fluid and electric current may flow through the coil simultaneously, an armature structure movably disposed within said coil for movement thereby and having an axial extension thereon adapted to support a hollow electrode, a fluid flow passage in said extension, and electric and fluid flow conducting means connecting one end of the conductor with said armature structure for movement therewith and communicating with the passage in said extension for conducting coolant fluid therethrough and electrically connecting said conductor and extension.

9. Metal working apparatus comprising an electromagnetic winding, said winding including a tubular metallic conductor in the form of a heli-

cal coil so that coolant fluid and electric current may flow through the coil simultaneously, the loops of said coil being separated so that the coil forms a spring, an armature structure movably disposed within said coil on the longitudinal axis thereof for movement thereby and having an axial extension thereon adapted to support a hollow electrode, a fluid flow passage in said extension, and an electrically conductive member having a fluid flow passage therein on said armature for movement therewith and communicating with the passage in said extension, one end of said coil being connected to said member and communicating with the passageway therein to provide an electric and fluid flow connection therebetween.

10. Metal working apparatus comprising a casing, an electromagnetic winding within said casing, said winding including a tubular metallic conductor in the form of a helical coil so that coolant fluid and electric current may flow through the coil simultaneously, the loops of said coil being separated so that the coil forms a spring, means fixing one end of said coil to the casing with the other end free with respect to the casing, an armature structure movably disposed within said coil on the longitudinal axis thereof for movement thereby, an extension connected to said armature for movement therewith and adapted to support a hollow electrode, a fluid flow passage in said extension, and an electrically conductive member mounted on said armature for movement therewith and having a fluid flow passage therein communicating with the passage in said extension, said other end of said coil being connected to said member and communicating with the passageway therein to provide an electric and fluid flow connection therebetween.

11. Metal working apparatus comprising a casing, an electromagnetic winding within said casing, said winding including a depending tubular metallic conductor in the form of a helical coil so that coolant fluid and electric current may flow through the coil simultaneously the loops of said coil being separated so that the coil forms a spring, means fixing the upper end of said coil to the casing with the lower end free with respect to the casing, an armature structure movably disposed within said coil on the longitudinal axis thereof for movement thereby, a depending extension connected to said armature for movement therewith and projecting through an opening in the casing and adapted to support a hollow electrode, a fluid flow passage in said extension, and an electrically conductive member mounted on said armature for movement therewith and having a fluid flow passage therein communicating with the passage in said extension, said lower end of said coil being connected to said member and communicating with the passageway therein to provide an electric and fluid flow connection therebetween.

12. Metal working apparatus comprising a casing, an electromagnetic winding within said casing, said winding including a depending tubular metallic conductor in the form of a helical coil so that coolant fluid and electric current may flow through the coil simultaneously, the loops of said coil being separated so that the coil forms a spring, means fixing the upper end of said coil to the casing with the lower end free with respect to the casing, an armature structure movably disposed within said coil on the longitudinal axis thereof for movement thereby, a depending extension connected to said armature for movement therewith and projecting through an open-

in the casing and adapted to support a hollow electrode, a fluid flow passage in said extension, an electrically conductive member mounted on said armature for movement therewith and having a fluid flow passage therein communicating with the passage in said extension, said lower end of said coil being connected to said member and communicating with the passageway therein to provide an electric and fluid flow connection therebetween, and guide means within said casing associated with said armature structure to guide the movement thereof.

13. Vibratory electromagnetic metal working apparatus comprising, a winding, an armature movably disposed adjacent said winding, a hollow metallic extension means projecting from said armature for engaging metal to be worked, one terminal of said winding being conductively connected to said extension means for controlling the energization of the winding while the device is used for working on metals, a field structure associated with said winding and armature for reducing the reluctance of the magnetic flux paths, resilient means biasing said armature and extension means to move to a predetermined position from which it is attracted when the winding is energized, means limiting the predetermined position to which the armature and extension

is moved by said resilient means, and an aperture opening through the metal engaging end of said metallic extension means and passing therein to a point for convenient connection with a source of coolant medium for flowing a coolant over the metal workpiece.

14. In a vibratory electromagnetic device for working on metals the combination of, a solenoid winding, said winding being wound of tubular metal so that a cooling medium may be circulated therethrough, a core armature reciprocally disposed in said winding, a hollow metallic extension secured to and extending from said armature for engaging metal to be worked, one terminal of said winding being connected to said extension, an enclosing field structure wound of thin sheet ferro-magnetic metal, end field walls closing the ends of said field structure, and one of said end walls having a central aperture through which the armature extension extends, guide means for guiding reciprocating movements of said extension and armature, resilient means tending to urge said armature core to a predetermined position from which it is attracted when the winding is energized, and means limiting the predetermined position to which the armature core is moved by said resilient means.

HENRY V. HARDING.