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HIGH FREQUENCY DENTAL TOOL

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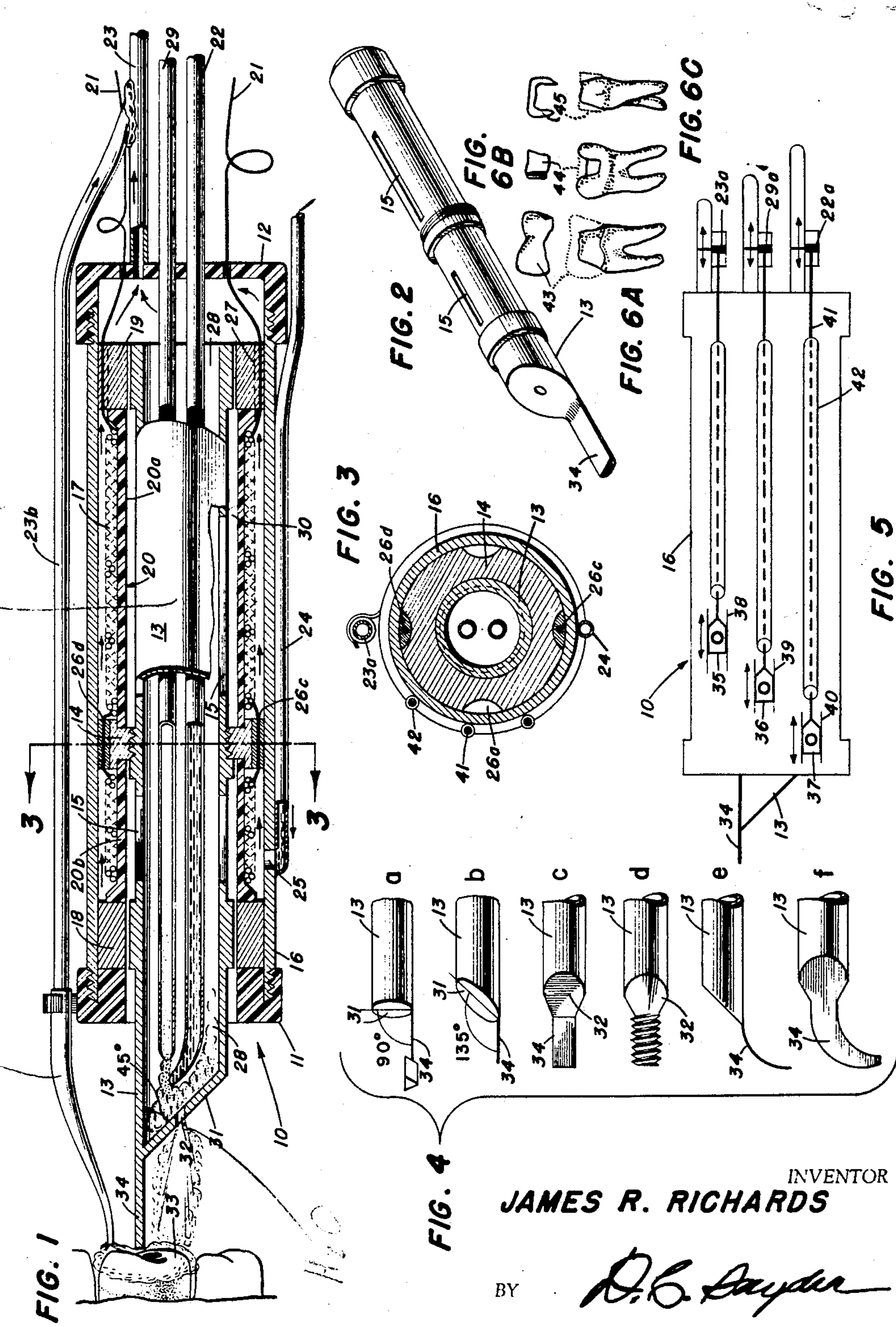

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HIGH FREQUENCY DENTAL TOOL

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to a high frequency dental tool and to a process of high frequency dental clinical work.

An object of the invention is the elimination of the slow, cumbersome, heat generating, inaccurate and painful dental drilling with the conventional rotating burr and the provision of a smooth, rapid and efficient excavation method, having no objectionable effects upon the patient and no shock-or-strain-effects upon the tooth drilled.

Another object of the invention is to apply high frequency low amplitude oscillations as the motive tooth excavation actuating power.

A further object of the invention is to employ in dental clinical work the method of motivating abrasives in suspension at a high frequency and acceleration and low amplitude against the tooth under excavation.

Still another object of the invention is a dental clinical instrument capable of packing a filling into a tooth excavation by high frequency oscillations.

Another object of the invention is to provide a dental excavating tool motivated by high frequency oscillations comprising its own fluid cooling supply and evacuation without damping the high frequency oscillations of the tool.

Another object of the invention comprises the provision of an abrasive and suspension supplying and evacuating means in the excavating tool.

A further object of the invention is to provide finger tip controls of the various supply and evacuation providing conduits, instantly and easily operable during the clinical work and without any interruptions.

Still another object of the invention is the provision of a dental tool, embodying the tooth excavating and filling functions here described, and also capable of accurate, easy performance in the limited working space of the mouth of the patient.

Another object of the invention is to provide a small light pencil-like drill enabling the operator to operate it with an artist's ease and fashion to excavate holes and channels of complex shapes with extremely close tolerances desirable for this type of work.

A further object of the invention is to use a premade inlay filling as a tip extension of the dental tool herein described to preform an excavation in the tooth, accurately fitting the inlay without the necessity of any repeated trial and error drillings required up to present.

Another object of the invention is to make it possible for the first time in dental industry to use premade dental inlays of fixed shapes and standardized sizes in filling teeth cavities more efficiently and less expensively than known up to present.

Other objects and advantages of this invention will become apparent from the following description and accompanying drawings in which:

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Fig. 1 represents a longitudinal section of the high-frequency dental tool showing parts in elevation;

Fig. 2 is a perspective view of the magnetostrictive tube;

Fig. 3 shows a cross-section of the device taken on line 3—3 of Fig. 1;

Fig. 4 shows elevations of modifications of the tip;

Fig. 5 is a diagrammatic view showing the valve controls;

Fig. 6 exhibits elevations of sample inlays correlated with teeth to be treated.

Referring now to the drawings like reference characters designate like or corresponding parts throughout the several figures.

The tool is shown in Fig. 1 as unit **10** and comprises in a preferred embodiment an outer tubular jacket **16** of soft iron with its working end closed by plastic cap **11** and its power inlet end closed by plastic cap **12**. Inside of the jacket is mounted a concentric magnetostrictive nickel tube **13**, over which at its nodal (center) point is attached a brass sleeve **14**, tightly fitting into the jacket, as shown in Fig. 3. The tube **13** is provided with longitudinal slots **15**, shown in Fig. 2. In the space between the jacket and the tube is a low impedance winding **17**, shown in Fig. 1 in two layers wound over a nonconductive spool **20**. The spool as shown consists of two sections **20*a*** and **20*b***, divided by and anchored with their inner ends in radial grooves of the sleeve **14**. The coil is wound uniformly over both sections, and Fig. 1 shows the outer coil sections connected through slot **26*c*** and the inner coil sections through slot **26*d*** in the sleeve **14**. This is shown in Figs. 1 and 3. The coil provides a magnetic field through an alternating current input **21**, which may be controlled for instance by a finger tip control switch or by a foot switch. Supported in the jacket at its ends are permanent magnet rings **18** and **19** with air gaps between them and the tube. The jacket, being made for this purpose of a magnetic material such as soft iron, completes the path of flux between the two magnet rings and the tube. The permanent magnet rings provide the bias necessary to prevent a reversal of the magnetic flux. Without this bias the tube would become alternately magnetized to vibrate at twice the frequency of the sine wave applied. The magnetic field induced must not exceed the bias field. It has been determined empirically that for optimum performance of the embodiment of the invention shown in Fig. 1, the biasing flux density should be about 60% of the saturation value, when applied at points of maximum amplitude. The magnetic bias may be provided for by other known means such as a direct current without departure from the scope of the invention. The magnetostriction causes the nickel tube **13** to expand and to contract longitudinally from the nodal point in both directions. Lateral expansions and contractions also occur simultaneously. The longitudinal slots **15** in tube **13**, shown in Fig. 2 serve to reduce the eddy currents. The amplitude of the magnetostriction depends on the magnitude and frequency of the electric current employed and on the harmonical relationship between the frequency applied and the natural mechanical resonance of the length of the tube. The width of the air gaps between the magnetic rings **18** and **19** and the tube **13** may be increased in proportion to the increase in the magnitude of the current input. In the embodiment shown in Fig. 1 these air gaps were empirically determined at 0.001" for satisfactory performance. An optimum magnetostriction is achieved when the length of the tube represents one half wave length of the frequency selected. The resonant frequency of the tube is determined as equal to the velocity of sound propagation through the particular material used in the tube, divided by two times the length of the tube. The speed of sound propagation in nickel being 16.320 feet per second, the wave length at 25 kilocycles is 0.326′=3.9″. At higher frequencies the tube should be shortened, at lower frequencies extended proportionally. A frequency at least above the audible range was selected to prevent undesirable noise productions, which could affect the patient adversely, however higher frequencies of approximately 25,000 cycles per second were found advantageous to the motivation of the present tool at approximately its 4″ length with 50 volts at 10 amperes. An acceleration of approximately 5,000 gravitational units is necessary but of approximately 10,000 gravitational units is preferable to operate the present tool at high efficiency with an amplitude of about 0.01 mm. The double-layered coil **17** in combination with the magnetic flux path comprised of the jacket **16** the permanent magnet biasing rings **18** and **19** and the magneto-strictive nickel tube **13** serve as the generator of the tool tip's reciprocating oscillations in this embodiment when the coil is energized by a conventional power supply having the desired frequency and amplitude characteristics. To prevent damping of the tube **13** at its ends and to allow for free end movements of the tube, the tube is supported within the jacket only by its nodal support and the caps **11** and **12** are spaced free of the tube to prevent any interference with the tube's magnetostrictive movements. The working end of the tube freely protrudes through cap **11** and is provided with an end wall **31**. The wall **31** is shown in Fig. *4a* at an angle of 90° and in Fig. *4b* at an angle of 135° from the tube's longitudinal extension **34**. The closure **31** has a hole **32** connecting the tube's interior **28** with the working area **33** of the tooth in the patient's mouth. The hole **32** therefore is strategically positioned for optimum results close to the tip of the tube to permit a flow of the fluids from the tube's interior by gravitation and adhesion as shown in Fig. 1. There may be several such holes **32** in the end wall, each providing an outlet for one or more interior conduit lines. One or more lines such as **23** and **24** may be connected from the outside of the jacket. The angle of 135° of the end wall with a tip of ½″ has been selected as sufficient to provide a freedom of movement of the tool within the patient's mouth and simultaneously to permit the hole **32** to function as a conduit of water from area **28** by gravitation upon the tooth. A portion of the wall of the tube may taper off past the end wall **31** into a working tip **34**, as shown in Figs. 2 and *4c*. When a changeable working tip is desirable an alternative arrangement is to provide the working end of the tube with means to fasten the tip to it, for instance by thread and screw, as shown in Fig. *4d* or by soldering or welding. A kit of tips of various shapes and sizes may be made available for every tool. In the alternative the tube itself may be made exchangeable for another with a different tip. The present tool may be used with abrasives such as aluminum oxide or boron-carbide, of minute particle sizes. Very good results were obtained with abrasives of particle size in the range of approximately 30 microns. Under operating conditions the abrasive is suspended in a fluid such as water or various oils to form in the working area of the tooth a mud of a consistency which may be quickly varied, for instance by the tool's fingertip controls, shown in Fig. 5 and hereinafter described. The high frequency and acceleration impact of the tip motivates the abrasive against the tooth area attacked by it and in the direction pointed by the dentist, as the immediate cause of the tooth excavation. The excavation proceeds at extremely close tolerances predetermined by the sizes of the tip and abrasive. The tip may be made of copper, nickel, iron or other metal sufficiently soft to permit the abrasive particles to embed themselves loosely in its surface, to be then by magnetostrictive acceleration propelled against the working area of the tooth; or the tip itself may have

abrasives such as diamonds pressed in its surface loosely or in a firm contact. The tip, when sufficiently thin as indicated for instance in Figs. *4b* and *e* may be used as a knife to slice off portions of the tooth laterally. Examples of contra angle types of tips, flat and edgewise, are shown in Figs. *4b, e* and *f*.

It will be readily appreciated that these contra angle tips make it possible for the first time in the history of dentistry to drill a tooth at any angle required by its usually twisted channels of decay and to follow them. Up to the present it was necessary to drill away large healthy portions of the tooth to gain access to the decayed tissues not otherwise accessible by the rotating burr. The contra-angle tips shown also are able to fill the irregular cavities by their magnetostrictively created impacts. The angle of the end wall **31** and the length of the tip **34** are selected to cooperate in providing optimum access and clinical working freedom in the patient's mouth. The length of the elongation **34** including any working tip attached thereto must be considered in the determination of the length of the tube at the particular frequency selected. The magnetostriction subjects the tube to lateral and longitudinal vibrations controlling the multivibrational directions of the tip.

Without the abrasive the tool may be used as an impact tool, for instance to fill an excavated tooth with gold foil. The foil is built up and packed into the cavity as a hardened mass by the continuous impacts of the tool.

The tool makes it possible to employ an unprecedented method of tooth filling with ready made inlays. According to the present invention an inlay of non-brittle material may be used at the end of the tip as the tip itself and will imbed itself into the tooth to be excavated, if abrasive is applied between it and the tooth. The inlay may be held in place against the tooth simply by the pressure of the tip, or the tool may include a conventional grasping mechanism. For instance the inlay may be held firmly in position on the tooth together with the tool's tip with a jig. The jig may rest on or be clamped to the surrounding teeth. Thus the inlay itself will be countersunk in the tooth to preform there a perfectly fitting cavity for itself with the closest possible tolerance. The inlay itself may be used to excavate the tooth and simultaneously form its own bed. It will be thereafter taken out, the cavity cleaned and the inlay reinserted and cemented in. Such a method is possible in a great percentage of tooth fillings. According to the present invention the inlays are to be mass produced in several standardized sizes corresponding to the most frequently encountered sizes of cavities to be filled. The inlay may be shaped with a larger bottom than top area, such as a frustated cone or pyramid and may be dovetailed into the tooth to anchor it more firmly. An example of such an inlay is indicated in Fig. *4a* showing at the end of tip **34** a triangular prism. A body of any other geometrical shape may be utilized as an inlay.

An altrenative arrangement is to provide the tip **34** itself with a premade extension of the same predetermined size and shape as an inlay to be inserted into the tooth, of which again Fig. *4a* is a demonstration.

In Fig. 6 are shown examples of unconventionally shaped inlays and how they may be fitted over teeth cavities with the present tool. Fig. *6a* represents a crown **43** which differs from the thin-shelled crowns used up to the present in that it is a combination of a crown and inlay. The conventional thin-shelled crown must be tailor made individually for each tooth, and even then its interior does not correspond to the surface of the tooth and does not repalce the excavated area. A brittle filler is used to build up the tooth within the shell. Often air cavities remain behind after the crown is cemented on and within a short interval the top of the crown, not having a solid support, is bitten through and must be replaced. The crown of the present invention shown in Fig. *6a* is a solid body having the conventional outer shape and a solid inner area replacing the excavated tooth portion. Up to present it would be almost impossible to fit a tooth with a premade crown of this type, since the dentist cannot see inside it, when fitting it over the tooth. It would be also impractical to individually make a crown body filling the excavated tooth area. The present invention makes it possible for the first time to use a premade crown of a standard predetermined size and shape comprising a solid inner body and an outer shell to countersink it over and into the tooth in one simple operation. Fig. 6B shows in front view the example of another type of an inlay **44** in the form of a U-shaped band as it fits over a tooth and Fig. 6C exhibits a side view of a similar inlay with its prong ends sharp and tapered like staples to take a firm grip in the tooth's body.

The various conduits of fluid supplies and exhausts may be valve-controlled by fingertips of the same hand holding the tool during its operation. Fig. 5 shows the unit **10** provided on the outside of jacket **16** with valve control knobs **35, 36, 37** slidable by finger tip control, each between a pair of rails **38, 39** and **40**. Each conduit is shown provided with a valve; the exhaust with valve **23*a***, the air line with valve **29*a*** and the water line with valve **22*a***, each connected to its respective slidable knob by a control wire **41**. Each control wire is protected by a tubular control wire guide **42**. As an example butterfly valves may be used comprising a diaphragm inside the valve housing with a spring loaded shaft controlled by the slidable knob to force the return of the valve into its original position upon release.

While magneto-striction has been utilized in the preferred embodiment of the invention shown, other sources of high frequency vibrations, such as mechanical, electrical, electromagnetic, piezoelectric or sonic may be employed as equivalent motive powers of the present dental tool, without departing from the spirit and scope of the invention.

The alternating current input lines **21** and various fluid conduit lines are admitted into the jacket either through cap **12** or through orifices in the jacket such as **25**. The coil **17** is shown in Fig. 1 cooled through conduit **24** circulating water through inlet **25**, slots **26*c*** and **27** as indicated by arrows, into the interior **28** of tube **13**. There the water cools the tube and is dispersed by the magnetostrictive motions and by gravity partially through slots **15** (shown in Fig. 2) into the air space **30** and partially through hole **32** into the working area **33** to cool the tooth under excavation and to keep the abrasive in liquid suspension. Lines **22, 29** and **23** are shown entering the interior of the tube through orifices in cap **12**. Lines **22**, supplying air, and **29**, supplying water, extend to the working end **31** of the tube and produce there by combined function and air-water spray penetrating through hole **32** upon the excavated tooth **33** to cool it. An additional line such as **29**, may be incorporated to supply the tooth with the abrasive either dry or in solution with water. An additional vacuum exhaust line such as **23*b***, may be extended to the area **33** to withdraw excess moisture and used up abrasive from the tooth excavated. The water which penetrates through slots **15** into the air space **30** and any excess of water in the interior **28** of the tube is withdrawn through the vacuum exhaust line **23** which efficiently increases the cooling of both the exterior and interior walls of the tube.

The advantages of the invention as here outlined are best realized when all of its features and instrumentalities are combined in the respective structures, but useful devices may be produced embodying less than the whole.

While the tool has been illustrated operable as a dental tool it is by no means limited to such purposes, but may be used for instance by artists, in sculpture, diamond setting, in providing artificial dentures with inlays to simulate teeth appearing convincingly true, etc.

It should be understood that the foregoing disclosure relates to only a preferred embodiment of the invention and that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purposes of the disclosure, which do not constitute departures from the spirit and scope of the invention set forth in the appended claims.

I claim:

1. A pencil like shaped dental tool comprising in combination an outer longitudinal jacket, an inner high frequency oscillating tube suspended within said jacket with a clearance at its working end, and protruding through it at its working end with an extended working tip for endwise free reciprocating oscillations of said tip, a generator of said oscillations, a power supply to said generator, and at least one fluid conduit and fluid supply and exhaust means connected with the interior of said tube.

2. A pencil like shaped dental tool comprising in combination an outer cylindrical jacket of magnetic material, an inner tube of magneto-strictive material protruding through said jacket at its working end with an extended working tip, said tube being centered within said jacket by a sleeve support for otherwise free magnetostrictive movements, a high frequency magnetostrictive oscillations exciting electric winding on a spool spaced within said jacket and over said tube, an alternating current supply flexibly connected through the conduit end of said jacket to said winding and two permanent magnet rings, each mounted inside one end of said jacket and spaced from the adjoining longitudinal portions of said tube.

3. A pencil like shaped dental tool comprising in combination an outer cylindrical jacket of magnetic material, an inner tube of magneto-strictive material protruding through said jacket at its working end with an extended working tip, said tube being centered within said jacket by a sleeve support for otherwise free magneto-strictive movements, a high frequency magneto-strictive oscillations exciting electric winding on a spool spaced within said jacket and over said tube, an alternating current supply flexibly connected through the conduit end of said jacket to said winding, two permanent magnet rings, each mounted inside one end of said jacket and spaced from the adjoining longitudinal portions of said tube, a plurality of fluid conduits of abrasive, abrasive suspending medium, and cooling and flushing fluid, said conduits connected with the interior of said tool for supply and withdrawal of said fluids, and an end wall at the working end of said tube provided with a hole connecting the working area of the tool with the interior of said tube.

4. A pencil like shaped dental tool comprising in combination an outer cylindrical jacket of magnetic material, an inner tube of magneto-strictive material protruding through said jacket at its working end with an extended working tip, said tube being centered within said jacket by a sleeve support for otherwise free magneto-strictive movements with clearance from the ends of the jacket at both ends, a high frequency magneto-strictive oscillations exciting electric winding on a spool spaced within said jacket and over said tube, an alternating current supply flexibly connected through the conduit end of said jacket to said winding, two permanent magnet rings, each mounted inside one end of said jacket and spaced from the adjoining longitudinal portions of said tube, a plurality of fluid conduits of abrasive, abrasive suspending medium, cooling and flushing fluids and air, said conduits connected with the interior of said tool for supply and withdrawal of said fluids, an end wall at the working end of said tube provided with a hole connecting the working area of the tooth with the interior of said tube, each of said conduits equipped with fingertip controls of said valves mounted on said jacket.

5. A pencil like shaped dental tool comprising in combination an outer cylindrical jacket of magnetic material, an inner tube of magneto-strictive material protruding through said jacket at its working end with an extended working tip, said tube being centered within said jacket by a sleeve support for otherway free magneto-strictive

movements, a high frequency magneto-strictive oscillations exciting winding on a spool spaced within said jacket and over said tube, an alternating current supply flexibly connected through the conduit end of said jacket to said winding, two permanent magnet rings, each mounted inside one end of said jacket and spaced from the adjoining longitudinal portions of said tube, a plurality of fluid conduits of abrasive, abrasive suspending medium, cooling and flushing fluid, said conduits connected with the interior of said tool for supply and withdrawal of said fluids, an end wall at the working end of said tube provided with a hole connecting the working area of the tooth with the interior of said tube, each of said conduits equipped with a valve and finger tip control of said valves mounted on said jacket, said end wall of said tube being tapered off toward the root of the working tip at an angle of less than 90°.

6. In a dental tool, a generator of magneto-strictive oscillations comprised of a coil member wound upon a spool of non-conductive material and flexibly connected to an alternating current supply, and a flux path consisting of a jacket member of conductive material concentrically disposed around said coil, a tubular tool holder element of conductive material having a plurality of longitudinal slots concentrically located within said coil, and a plurality of permanent magnet biasing rings mounted within said jacket and separated from the tool holder by air gaps; the magnetic bias of the permanent magnet rings, the size of said air gaps, and the length of the tubular tool holder being determinative of the frequency and amplitude ratings required of the alternating current supply.

7. In a dental tool, a generator of magneto-strictive oscillations comprising a double-layered coil wound upon a spool of non-conductive material and flexibly connected to an alternating current supply, a flux path consisting of a jacket of conductive material concentrically fixed about said coil, a tool holder of conductive tubular material having a plurality of longitudinal slots therein, said tool holder being concentrically located within said coil and fixed at its midpoint for symmetrical oscillations, and a plurality of permanent magnet rings mounted within said jacket so as to form air gaps between the jacket and tool holder, said permanent magnet rings providing a bias for the magnetic field setup by the coil when it is energized.

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