ABSTRACT: A method and apparatus in which ultrasonic energy in combination with high-velocity liquid jets provides a system for cleaning of teeth as by the removal of tartar, calculus deposits, stubborn stains, such as are produced by smoking, and simultaneous stimulation of the gingival or gums. The applicator through which the liquid jet stream passes may also be ultrasonically vibrated for engagement with the tooth and gingival structures or the oral cavity to impart thereto microfatigue and ultrasonic impact grinding action for the removal of foreign substances from the teeth and a micromassage of the gingival structure for stimulation thereof.
METHOD AND APPARATUS FOR MAINTAINING TOOTH AND GINGIVAL STRUCTURES WITH ULTRASONIC ENERGY

BACKGROUND OF THE INVENTION

This invention relates generally to the hygienic care of the oral cavity, and more particularly to methods and apparatus utilizing ultrasonic vibratory energy for removal of foreign substances from teeth and the treatment of the gingival tissues within the oral cavity.

The applicant has already participated in earlier developments in ultrasonic periodontal applications which have led to U.S. Patent Nos. 3,075,280, 3,076,904 and 3,213,537, and U.S. Patent No. 3,375,820 of Balamuth and Kuris issued April 2, 1968, for Methods and Apparatus for Ultrasonic Cleaning of Teeth and referred to as generally the "ultrasonic toothbrush.

This latter invention may be used in conjunction with ultrasonic brush heads as disclosed in U.S. Patent No. 3,335,443, issued Aug. 15, 1967, to Parisi et al.

We are concerned with the present invention with new discoveries by applicant which allow dramatic improvements in the application of ultrasonic energy for periodontal procedures. Before proceeding to the details of the invention, let us first review briefly generally known facts of oral hygiene.

Let us first look at the oral cavity with its teeth structure and gingival surfaces formed by the gum structure and review the situation as to objectives to be achieved. In the first place, ordinary tooth brushing uses bristles and tooth paste to keep tooth surfaces clean and hopefully, polished and bright (including "whiteness"). In addition an attempt is made to clean out interproximal, gingival crest, or gumline areas, and other hard-to-get-at areas (without too much success). Finally, under dental teaching, the tooth brusher learns how to stroke the gingival-tooth boundaries so as to provide some gum stimulation. The now successful electric-vibratory, i.e., 60 cycles per second, tooth brushes attempt to meet all the above goals, only with more efficiency and with the aid of outside electrical energy to aid the bristle motions during use.

In practice, I believe it is safe to say that the above methods are of limited usefulness, but do not make a basic attack on fundamental factors believed to be involved in periodontal disease. Let us remember that with advancing life expectancy, the loss of teeth and improvement of health is due more to periodontal causes than to simple dental caries. It was with this in mind that the water massaging device process or idea was introduced and it is having considerable success, because it is able to perform interproximal and other cleaning not possible to ordinary and electric tooth brushing. The water massaging device process is generally discussed with reference to U.S. Patent No. 3,227,156, for Method And Apparatus For Oral Hygiene. In addition, it provides gingival stimulation on a regular basis which also outpaces the previously-mentioned techniques. Basically, the water massaging device idea is the use of liquid jet forces on an intermittent basis whereby the "magic bullets" of water go to work to clean teeth and stimulate gums.

Now, none of the methods mentioned so far, do anything to prevent or remove tartar or calculus deposits, or remove stubborn stains such as are produced by smoking. For instance, ultrasonic energy has been called into play here, in order to fill these missing gaps, and this is in part the subject of copending application, Ser. No. 513,491, filed Dec. 15, 1965, now U.S. Patent No. 3,326,525, of Balamuth et al., referred to above. Vibrating bristles (with water or water + paste or other agents) are introduced to create the unique forces of cavitation, impact grinding, honing and polishing, and soft tissue vibration as a gingival stimulant. In addition, the vibrating bristles also perform the functions of ordinary toothbrushes and electric toothbrushes, as well. Thus, a complete armamentarium is made available to attack the original problem to be solved, namely, adequate home aid to good periodontal and tooth care. The basis has been laid for a sound dental care system, whereby both the dentist and the home appliances combine to make possible a new kind of preventive dentistry.

Table 1 below was provided in order to more clearly distinguish the present invention from known systems or techniques of oral hygienic methods and to indicate those particular beneficial actions obtainable with the present invention. In the left hand column various parameters generally considered in evaluating oral hygienic systems are listed. Five systems are listed with the relative ability of each system, relative to the other to attain the best results. As will be seen by a review of the table, systems 1, 2, and 3 are deficient in a number of respects as for example, calculus removal and medicament absorption. System 4, which is the ultrasonic toothbrush, is an improvement over systems 1, 2 and 3, but still does not perform as well as system 5, which is the present invention. In respect to certain parameters, for example, the interproximal cleaning of soft debris by the micropulsed jet of the present invention, produces additional action to dislodge debris as compared to a macropulsed or continuous jet of liquid as in the pulsating jet system. Further, although the ultrasonic toothbrush, of system 4, does a good job of interproximal cleaning, the ability of the individual bristles to penetrate the depths between the teeth does permit certain foreign substances to remain. Further, the microstimulation attainable by the micropulsed jet stream of system 5 permits the micromassage action to take place in areas where the bristles of the ultrasonic toothbrush do not always reach.

Thus, in accordance with the present invention, the best of all the oral hygienic parameters are combined to produce a new and novel system that is superior to any system available for treatment of the oral cavity.

TABLE 1.—TYPE OF SYSTEM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Toothbrush and dentifrice</th>
<th>Electric toothbrush</th>
<th>Water massaging device or equivalent</th>
<th>Ultrasound toothbrush</th>
<th>This invention</th>
</tr>
</thead>
<tbody>
<tr>
<td>General removal of soft, non-adherent debris</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Interproximal cleaning of soft debris</td>
<td>Poor</td>
<td>Very good</td>
<td>Good</td>
<td>Rate &gt; 4</td>
<td>Rate &gt; 4</td>
</tr>
<tr>
<td>Stain</td>
<td>Moderate for some stains</td>
<td>&gt;1</td>
<td>&gt;2</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Calculus (tartar)</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Gum micromassage</td>
<td>Moderate</td>
<td>&gt;1</td>
<td>&gt;2</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Polishing action</td>
<td>Dependent on dentifrice</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Whitening action</td>
<td>Solely dependent on dentifrice</td>
<td>Same as 1</td>
<td>Same as 1</td>
<td>Same as 1</td>
<td>Same as 1</td>
</tr>
<tr>
<td>Medicament absorption</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

5,347,110
3,547,110

OBJECTIVES OF THE INVENTION

An object of the present invention is to provide improved methods and apparatus for performing oral hygiene procedures with ultrasonic energy.

Another object of the present invention is to provide novel and improved cleaning techniques for personal oral hygiene care which enables the user to control and obtain significantly better cleaning of teeth.

Another object is to provide new and novel methods and apparatus which are embodied in a device that is completely safe for use by adults and children in the home on a regular basis.

Another object of the present invention is to provide new and novel methods and apparatus for regular personal oral hygiene care which provides excellent cleaning results in the hard to reach interproximal and gumline areas in general, and simultaneous gum stimulation.

Another object of the present invention is to provide improved cleaning techniques for the removal of plaque, tartar, calculus, stubborn stains, interproximal soft debris by a microfatiguing action.

Another object of the present invention is to provide improved techniques for maintaining by micromassage the healthier tonus of the gingival tissue.

Other objects and advantages of this invention will become apparent as the disclosure proceeds.

SUMMARY OF THE INVENTION

The present inventor has discovered that although the ultrasonic and the water massaging device methods have, so to speak, laid the foundations for a whole new approach to oral hygiene, an important advance in the art is obtained by achieving a proper combination of the "magic water bullet" with ultrasonic energy superimposed thereon or in combination with the ultrasonically vibrating bristles. The inventor has discovered that it is not necessary to have a plurality of bristles in order to achieve the most basic requirements of advanced home dental hygiene, i.e. the removal of plaque, tartar (calculus), stubborn stains, interproximal soft debris, and the stimulation of gingival tissue to healthier tonus. It can be achieved by a single ultrasonically vibrated nozzle, preferably having a continuous or pulsed stream of liquid passing therethrough.

What is necessary is the kinetic energy of a water stream, such as in a water massaging device system which term is used herein in the generic sense, type of approach provides, combined with an injection of ultrasonic energy over a large enough surface to guarantee presence of significant amounts of cavitation energy as well as the material removing energy of high frequency vibration combined with an artificial or self-induced slurry. At the same time, if the ultrasonic vibrations are adequately transferred by a microfatiguing action to the plaque and calculus, there is, in addition to the impact grinding kind of material removal, the complementary process of material removal of weakly bonded deposits such as plaque and calculus by means of microfatigue effects. The removal of material in a solid state is generally discussed in applicant's U.S. Pat. No. 3,145,450, for Method Of Ultrasonic Removal Of Material By Fatigue Failure.

BRIEF DESCRIPTION OF THE DRAWINGS

Although the characteristic features of this invention will be particularly pointed out in the claims, the invention itself, and the manner in which it may be made and used, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part hereof, wherein like reference numerals refer to like parts throughout the several views and in which:

FIG. 1, is a chart indicating the relationship of the various principal factors related to ultrasonic microstimulation for oral hygiene;

FIG. 2, is a perspective view of an ultrasonic jet type oral hygiene unit embodying the present invention;

FIG. 3, is a section through the supply means of FIG. 2 taken along the lines 3-3;

FIGS. 4 and 5, illustrate the appliance means of the present invention in relation to the gingival and tooth structures of a human to obtain a cleaning action, and helpful in explaining the operation of the present invention;

FIG. 6, illustrates the applicator brushing instrument in accordance with the present invention in which the combination of bristles and jet stream is employed;

FIG. 7, is an assembled view, partly in cross section, of the ultrasonic cleaning instrument according to the present invention;

FIG. 8, is a sectional view through the ultrasonic handpiece of FIG. 7, taken along the line 8-8;

FIG. 9, is a sectional view of an applicator in the form of a brush;

FIG. 10, is a sectional view of another form of applicator insert in accordance with the invention; and

FIGS. 11 and 12, illustrate modified applicator constructions.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to the drawings, FIG. 1 is a chart illustrating the various principal factors of the invention. The microstimulation effect is divided into micromassage stimulation of the gum structure or gingival tissue, and microfatigue effects on tooth structure such as dentin, enamel and fillings. In effect this diagram is an elucidation of the invention into separate but simultaneous, or concurrent, actions on hard tissue and soft tissue. Also the acting agencies must be divided into high kinetic energy, low frequency hydrodynamic action of liquids and the action of ultrasonic energy through cavitational and other effects.

These various combinations are attainable by providing the jet stream that has superimposed thereto an ultrasonic acoustic energy waves to produce the micromassage of the gum structure and the removal of foreign deposits from the tooth structure whether adhered thereto or contained interproximally therewith.

By simultaneously vibrating the ultrasonic frequency range and its engagement with the gingival and tooth structures the cleaning action is enhanced by the mere combination of the kinetic energy and ultrasonic vibrations and further by the inducement of cavitation action and impact grinding effects for the removal of foreign substances.

Turning now to FIGS. 2 and 3 there is illustrated an oral hygienic unit 10, which will be described in greater detail hereinafter, and for present purposes it is sufficient to indicate that it includes an instrument or handle means 12 adapted to be held by the user in a conventional manner, having extending from one end thereof supply means 14 which supplies to the instrument means 12 both power and a constant supply of fluid. Applicator means 16 extends from the opposite end of the instrument means 12 and has a passageway extending therethrough and in communication with the supply means 14 to permit the formation of a jet stream of liquid 15 of a small cross-sectional area, generally in the diametrical range of 0.010 inch to about .070 inch. The fluid generally in the form of a liquid passed through the instrument means 12 and is passed through ultrasonic motor means 18 (see FIG. 7) and has transmitted thereto high frequency mechanical energy, so as to obtain a micropulsing of the stream of liquid 15 in the ultrasonic frequency range.

The velocity of the jet stream 15 may be controlled by employing pumping means 20 which continuously supplies liquid 21 from the reservoir means 22, either continuously or intermittently, to create low frequency energy pulses to obtain a
3,547,110

macropulsing action. Generating means 24 is provided to convert the current, i.e., 60 cycle, to a frequency in the ultrasonic range, which for purposes of the present invention, "ultrasonic" is defined to include the range of approximately 5,000 cycles per second to 1,000,000 cycles per second, although the micropulsing of the liquid stream is preferably in the range of approximately 16,000 cycles per second to 40,000 cycles per second.

The oral hygiene unit 10, may be controlled such that the liquid stream may be continuously pumped at a constant rate of flow with the ultrasonic energy transmitted thereto to obtain the micropulsing action, or the liquid stream may be simultaneously pumped to obtain the macropulsing action as well. Which technique is selected will vary with the users condition of his tooth and gingival structures.

To power the unit 10 we have a plug 27 and cord 28 which is in communication with the generator means 24 and pumping means 20. Switching means 26 contains a first switch 30 connected to the generator 24, in a conventional manner, for providing power for energizing the ultrasonic motor contained within the instrument casing 32 of the hand held instrument means 12. The energy from the generator is transmitted to the ultrasonic motor by wires 33 and 34 extending through the flex factors of a liquid supply means.

A second switch 31 is provided to control the pumping action of the liquid supply, such that both the velocity as well as the pumping cycle is controlled. Although reservoir means 22 has been shown in communication with the pumping means 20, it is to be understood that essentially both might be considered the equivalent of a water tap under normal pressure that is controlled as to volume by the conventional control of the faucet, found in the home. But to obtain controlled velocities of the jet it is preferable to provide both reservoir and pumping means. The switch 31 is provided to regulate, in any conventional manner, the pumping means 20 to provide a stream of the fluid 21 through the tube 37 which is contained in the conduit 35, through the ultrasonic motor and then exiting from the applicator means 16 in the direction of arrow 38 in the form of jet stream 15. The applicator means 16 may take various shapes and forms to permit its positionment within the oral cavity. The applicator means 16 may also be coupled to the ultrasonic motor to induce therein ultrasonic energy waves in the direction of double headed arrow 40.

In the previous embodiment of the present invention as shown in FIGS. 4 and 5, and the engaged structure. The jet stream 15 which is generated by means of the pumping means 20 is of a relatively small cross-sectional area and as the liquid is passed through the supply means 14, and in turn through the instrument means 12, high frequency ultrasonic energy is superimposed on the stream of liquid so as to obtain a macropulsing action thereon. Accordingly, the stream of liquid is then moved to substantially engage the tooth or gingival structure of within said cavity and it is moved at such a rate, dependent upon the user, to obtain a microstimulating of the engaged structure by transmitting the ultrasonically micropulsed energy waves contained in the jet stream 15 to effect a cleansing action thereof. In this manner a level of hygiene control may be maintained in the oral cavity.

Accordingly, the action obtained by the jet stream in the form of micromassage may be divided into various subcategories which have been illustrated with respect to FIG. 1. Particularly, we have the ability due to a microfatiguing action to remove foreign deposits or, substances 50, normally found on teeth which may be generally characterized as stain, plaque, calculus or tartar. Stain and tartar are both adherent deposits on teeth but plaque is somewhat softer and less adherent, such as soft food deposits found between or on the teeth. The ability of the jet stream to engage these hard foreign deposits brings about this microfatiguing action in such a manner such that the bond between the teeth structure and the foreign deposits is weakened by the high frequency energy pulses to the extent that it is broken and the resultant deposits are flushed away by the continuous stream of liquid.

In this manner it has been shown that the ultrasonically continuous or pulsed jet can remove tartar deposits whereas other hygiene systems, hereinabove discussed, have been substantially ineffective. In addition it also removes stain and interproximal deposits in a significantly superior fashion, these improved cleaning results are believed directly related to the ability to continuously supply at an ultrasonic rate micropulsed energy to fatigue the bond between the tooth structure and foreign deposits to obtain the latter's removal.

In addition the microstimulation concept also takes another form in its ability to remove the well-known microfatigue deposits by the well-known microstimulation techniques. This is brought about since the jet stream, which is ultrasonically vibrated produces various cavitation action in the area in which it is directed. This is directly related to the high frequency acceleration which further enhances the cleaning action effect and will also assist in the removal of foreign deposits.

As indicated with respect to FIG. 1, we also have what is generally known as an impact grinding effect which materially assists in the removal of the foreign deposits. This effect, discussed in more detail in U.S. Pat. No. 2,580,716, in which applicant is the inventor, is generally exhibited in the presence of a cavitating field in addition to material-removing particles. In order to obtain the desired removal effect it is just necessary to bring the vibratory surface of the applicator means 16 into lightly engaged contact with the surface of the structure to be treated and in the presence of the material-removing particles. This may take the form of various denticrines which are used to contain certain particles which may be employed in the cavitation field. When this is done, cavitation is carried out by the use of merely the jet stream, at the proper velocity and pressure, this action will take place by the accumulation of the removed foreign deposits which in turn act as their own grit material and form a basis for the impact grinding process.

Simultaneously with the results obtained by microfatiguing we simultaneously have the action obtained by micromassaging of the gum structure of the organic oral cavity. The jet stream as previously indicated has superimposed thereon ultrasonic vibrations in the range of from 5,000 to 10,000,000 cycles per second and at the same time this stream might be simultaneously pulsed at a defined low frequency to obtain a macropulsing thereof. This low frequency macropulsing is generally in the range of 6 cycles per minute to 26,000cycles per minute. This permits a combination of effects to be obtained since the macropulsing has certain known beneficial aspects, and the micropulsing has others, which when combined produces results in the maintenance of the condition of the oral cavity not heretofore obtained.

The micropulsing action produces a micromassage of the treated gingival structure in that the actual energy waves are transmitted to the gingival structure for pervasively penetrating and treating the gingival structure for hygiene control thereof. In this manner penetration is obtained to a greater depth than available with macropulsing such that ample stimulation and invigoration of the gingival structure is most desirable, is obtainable. The actual treatment time, energy level and jet velocity is selected dependent upon the age and condition of the gums of the user, and might be varied so that...
Applicant has discovered that these resting times may be established by macropulsing the jet stream 15 or the equivalent of such “resting times” may be realized in another fashion for other kinds of wave energy therapy for both sonic (500 to 16,000 cycles per second), low ultrasonic (16,000 to 600,000 cycles per second), and high ultrasonic (600,000 to 10,000,000 cycles per second and higher) frequency ranges. By placing a vibrator in, say, the tank circuit of an amplifier it is possible to generate “bursts” or “bursts” of vibrations at the resonant frequency of the transducer being used. This is easily accomplished by one skilled in the art by merely keying the oscillator or electronic means being used to feed energy to the transducer. The point is, that it is readily possible to design the system so as to preselect the length of time of the “burst” or “pulse”, and also the length of the resting time between bursts.

For example, in superficial types of treatment such as with gums, it is possible to use very high ultrasonic frequencies which will not penetrate very deeply without absorption. The heat generated by a single pulse will be well dissipated if the waiting time for the next pulse is long enough. In this way, the superficial body areas may be treated with special applicators, whereby the chief effects produced are those due to the coherent wave energy which the pulse contained in the jet stream gives to the tissue. The heat produced by absorption dissipates and here there is no real thermal effect, such as a significant temperature rise in the tissue. For example, consider 60 pulses per second switching to 1 mc. waves where the tank Q of the amplifier allows, say 100 complete oscillations to one bunch of resonant vibrations.

The resting time may vary with respect to the treatment time and therefore considerable intensity of wave energy may be contained in a “pulse” or “burst”, which is many times what the tissue could tolerate if the wave treatment were continuous. We have here a kind of magic ultrasonic bullet, which may be directed for a tremendous variety of purposes into the gingival structure. It is to be understood that a variety of applicators may be employed for ultrasonic treatment by my method, and also the ratio of “resting time” to “treatment time” may be infinitely varied. For the treatment of given gingival conditions or diseases a frequency and intensity is selected that is compatible with the purpose of the treatment.

In order to understand the unique intercoupling actions involved in this invention, it is important to understand the transmission of the energy waves to the gingival tissue for massage and other treatment thereof. In the first place the acoustic impedance of gingival tissue and water are fairly well matched, so that water or water-like liquids provide an excellent medium by means of which ultrasonic vibrations may be transmitted into tissue from a solid vibrating source.

In order to gauge the intercoupling effects still further, let us look at some quantitative data involved. The water massing device type of action is optimum at about 1,200 pulses per minute or 20 pulses per second. A good water massing device rate of flow corresponds to about 5 cm/sec. Since there are 20 pulses per second, then there must be 5/20 or 0.25 gm. of water in each pulse. The kinetic energy of each is:

\[ KE = \frac{1}{2}mv^2 \]

but since the density of water = 1 gm/cm³, we can say the mass, m, of a pulse equals the volume of water charged in one pulse. Now if the orifice or jet area A, then the volume of the pulse is A L, where L is the pulse length. But the pulse length

\[ L = \frac{v}{a} \]

Where v=velocity of jet, t=time for one pulse. Now we have 20 pulses per second as a preferred value, therefore, \( t = \frac{1}{20} \) sec. and so \( L = \frac{v}{b/20} \).

And so the volume of one pulse is:

\[ A L = \frac{Av}{20} \]

This is also the mass of the pulse in grams for water. So we get:
A preferred nozzle size is approximately 0.03-in. diameter or 0.076 cm. This gives an A of 0.0045 cm². Also under the condition herein described it is easy to determine that v = 1,000 cm/sec. (this is about 33 P.F.S.). Also:

\[
(5) \ \text{K.E. (1 pulse)} = \frac{A}{40} v^2 = 10^9 \text{ ergs} = 10^{-2} \text{ joule/pulse}
\]

And for 20 pulses per second the power input to the gingiva by a typical high speed water massaging type jet is:

\[
(6) \ \text{Power} = 20\text{ pulse sec} \times 10^2 \text{ joule/pulse} = 2 \text{ watt}
\]

Now of this two-tenths of a watt input to the gingiva only a small fraction is absorbed as actual massage energy. Let us now turn to the ultrasonically vibrating jet and let us assume we have a very modest amplitude of vibration of 0.0003 cm at 30 K/sec.

Acoustic waves of this amplitude set up in water correspond to a sound intensity of:

\[
(7) \ I \approx \frac{5}{2} p c \ \text{watt cm}^{-2} \ \text{ sec} \ \text{cm}^2
\]

For a jet orifice of 0.0045 cm² we get a power input into the water of the jet pulse of about 0.1 watt. But this is ultrasonic power in a well-matched medium for gingival tissue and so we can expect that the superimposed ultrasonic vibration will convey at least as much microstirulation to gingival tissue for micromassage as the pulsed jet will give micromassage at the same time.

This calculation does not include the additional micromassage arising from the contact of the smooth end of the vibrating tip or applicator tip against the gingival tissue. Thus, we see that, in a unique way, the combination of the high-speed jet with the ultrasonically vibrating applicator tip yields an unexpected bonus of gingival treatment which is not present either in the water massaging device or the ultrasonic toothbrush. Together with the other advantages arising from the combination described in this invention, we have therefore transcended a simply additive combination and have arrived at a truly novel improvement in oral dental hygiene.

Having pointed out the benefits of the micropulsed energy jet, it should be indicated that this jet may now be combined with a direct coupling of the energy which is simultaneously transmitted through the applicator directly to the treated structure. Particularly the apparatus, as hereinafter described in detail, may be so constructed that the instrument is designed that the applicator is simultaneously vibrated in the ultrasonic frequency range as indicated by arrow 40 in FIG. 1. The vibratory component may either be elliptical, longitudinal, torsional, or any combination thereof, and may be transmitted by applicator means directly to the treated surface.

As indicated in FIG. 6, stimulent means 52a, which includes a plurality of individual resilient stimulent or bristle members may be coupled to the applicator means 16a for transmission of the mechanical vibrations. The advantages of utilizing the applicator means 16a in substantial engagement with the treated structure, irrespective if it is in the form of a single stimulent which is essentially what is shown in FIG. 2, or a plurality of stimulants as shown in FIG. 6, pertains to the basic configuration such that the liquid jet 15a of the micropulsed energy waves is contained proximate the filaments such that we obtain the combined effects in a manner to obtain the coupling or transimission of the energy treated structure in two wave forms, i.e., through substantial direct engagement of a solid member and through a liquid medium directed at a predetermined pressure such that we are able to combine in a single instrument the beneficial effects attributable to the transmission of energy through a substantially solid member, which is in the form of one or more filaments, and of a relatively flexible or compressible member in the form of the liquid jet.

Utilizing the brushing implement of FIG. 6, and as hereinafter discussed with respect to FIG. 9, the brush head is inserted in the mouth of the user and moved across the gingival surfaces to engage both the tooth and gingival structures 45a and 46a, with the stimulent or bristle cluster in relatively light contact with the tooth surfaces 45a and the gingival surfaces 49a as well. As the applicator implement 16a is manually moved throughout the mouth the liquid jet stream 15a is continually forced thereagainst to simultaneously engage the desired surface structures. The individual stimulent, or if a plurality of clusters are employed, they assume different positions and permit the removal of foreign deposits that are obtained on the tooth surfaces or interproximal as indicated in FIG. 5. Thus, we have in effect a microstirulation which includes a microsifting of the foreign substances by transmitting the micropulsed energy waves contained in the stream against the tooth structure for a period of time to fatigue the bond between the tooth structure and the foreign deposits and effect the removal thereof or a simultaneous utilization of impact grinding processes which will assist in this removal. We also have the ability to obtain a micromassaging of the gingival structure by the ultrasonically micropulsed energy stream which pervasively penetrates and treats the structure for the use required. This dual effect obtained by the microstirulation, removes interproximal and gum line foreign substances as well as those adhesions to the surfaces of the teeth as well.

The rate of removal will be dependent upon the accumulation to date and whether or not the patient requires primarily gingival stimulation or removal of materials, in either case he directs the particular jet stream in the direction he so desires.

In order to practice the novel combination or methods discussed hereinabove, in a practical manner to accomplish the desired objectives, it is preferable to provide an ultrasonic motor of low cost, when mass produced. Also, it is important to limit the amount of ultrasonic vibrational energy so that an overzealous user may not wear away the surface or damage the gum structure along with the stubborn stains or calculus. All the requirements cited above may be realized further by using a suitable instrument including plastic components which may be designed to be self-limiting vibrational energy transmitters, and at the same time, which are also capable of delivering the continuous pulsating jet stream of liquid to the work site.

In FIGS. 7 through 12, there is shown various embodiments of ultrasonically driven instruments in accordance with the principles of the present invention. As seen best in FIGS. 7 and 8, the instrument means 12 comprises two basic elements, namely an applicator insert 53, and a handle unit 54 for receiving the insert 53 and which together form in part the ultrasonic motor means 18.

The pumping means 20 of the system produces a stream of liquid and the instrument means 12 forms a passageway 72 to transmit the stream of liquid by means of the applicator means 16 which has a continuing passageway therethrough for applying the jet stream 15 to the structure to be treated in the direction of arrow 38. The ultrasonic motor means 18 contained within the instrument means 12 superimposes on the liquid stream mechanical vibrations in the ultrasonic range to the form micropulsed energy waves therein. The generator means 24 may be set to provide rest periods by pulsing or modulating the energy waves at a frequency in the ultrasonic range. At the same time the pumping means 20 may be set to provide
The handle of the instrument passageway 73 extending therethrough, which forms part of the fluid flow passageway 72, and which carries the metallic strips or layers thereon. The metallic material may be bonded to the plastic by several available methods, including electroplating, epoxy bonding and the like. It is of course necessary to supply the nickel coat in such a way that no complete rings or circles of metal are formed. This is to minimize eddy currents. Also it is possible to cut the tube which contains a suitable binder for binding both the support member and nickel together to the underlying plastic. The acoustic element 70 could be glass for sanitary reasons and for high-Q, high efficiency vibration. But if glass is used definite limitations must be inherent in the driving generator. The sidewall of the acoustic element 70 may also have bonded to it a piezoelectric or magnetostrictive pickup element in order to keep the motor automatic in its resonant frequency operation.

In practice the generator may be as small as 5 or 10 watts into the ultrasonic motor, and is preferably in the solid-state type. The forward end 75 of the acoustic element 70 is provided in the conduit 73 with a threaded portion 76 which is adapted to be engageable with the applicator member 16. The applicator member 16 includes an applicator member 80 which at its rear portion 81 is provided with a complimentary threaded portion 82 for engagement with the threads 76. As seen in FIG. 7, the applicator member 80 may include a forward portion 83 which is tapered with respect to the rear portion 81 of the applicator. The applicator member 80 will have an applicator passageway 74 continuing therethrough, and is hollow throughout its entire length to permit the liquid which is being passed through the instrument passageway 73 of the applicator insert 53 to continue in its path to the working or output surface 84 of the applicator means 16. The angular relationship between the forward portion 83 and rear portion 81 of the applicator member 80 will be dependent upon the amplitude of vibration of the output surface 84 as well as the configurations of the vibrational pattern desired to be obtained thereat.

Accordingly, the applicator insert 53 which has the fluid passageway 72 extending therethrough is designed such that the acoustic element 70 is positioned in energy transferring relationship to the instrument passageway 73, so that the ultrasonic mechanical vibrations are continuously transmitted to the stream of liquid as it passes therethrough. The applicator means 16 includes the applicator passageway 74 extending therethrough and which is in communication with the instrument passageway 73, such that essentially the passageway 72 is formed by the instrument passageway 73 and the applicator passageway 74. Depending on the design of the system, the energy waves may be introduced into the liquid stream in either of said passageways.

Thus, one complete magnetostrictive system would include an acoustic element 70 comprising a properly coated tube member formed of any suitable material capable of supporting vibrations transmitted thereto from the magnetostrictive coating. This will include many metals and hard plastics which are suitable for this purpose. In order to operate most efficiently, the length of the magnetostrictive strips 71 should be equal in length to an integral number of half wavelengths of the material at the frequency of vibration. A suitable material enabling the length of the acoustic element 70 to be maintained within reasonable limits is nickel, but it will be understood that other materials may also be used.

As to a further construction of the applicator insert 53 the acoustic element 70 may also be made from Pyrex glass tubing. On the surface of this tubing a silver metallizing paint is baked on and then nickel plating is placed on the metallized surface. Slotting of the nickel coating is provided by masking the Pyrex tube surface during silver metallizing. This manufacture lends itself to automated mass production. The hollow tube output end of the glass tubing provides a means for attaching a lightweight metal element to receive screw-on plastic or other working tips. The hollow tube also lends itself to through-feed of liquid mediums. The coupling to the casing
may be accomplished with O-rings or variants of other type mountings. Much simpler, of course, would be permanently attached working tips. In this case the whole insert must be inexpensive enough to be replaceable at suitable intervals by buying new ones. The plated glass tube type transducer would lend itself pretty well to this type of approach.

Now, in addition to the complete system we may include in the handle 54 into which the applicator insert 53 is assembled in addition to the energizing winding, pickup winding in the form of a permanent magnet (not shown) to bias the acoustic strips 71. Now, in addition to this we also have the hydraulic system which includes the reservoir means 22 and a suitable electric pumping means 20, which arrangement was previously discussed with respect to FIGS. 1 and 2.

Front support means for the applicator insert may include a radial flange in the form of an O-ring 85 which prevents the vibrations induced in the applicator insert 53 from being transmitted to the handle portion 54.

FIG. 9, shows applicator means 16a which includes stimulant means 52a in the form of a plurality of bristle clusters 90a in spaced-apart relation and coupled to the applicator member 80a in any conventional manner, as for example, in accordance with the teachings of U.S. Pat. No. 3,315,443. The applicator member 80a includes a rear portion 81a having threads 82a for securement to the acoustic element. The forward portion 83a is integral with the output portion 84a from which issued the latter the exterior end is substantially normal thereto. The fluid passageway or conduit 74a tapers downwardly and terminates in a plurality of apertures 91a through which the liquid flows to form a plurality of spaced-apart jets 15a between or in spaced relation to the respective bristle clusters 90a. In this manner as explained with reference to FIG. 6 combined effects may be obtained in using a jet and bristles with the jet in spaced-apart relation to the treated structure.

FIG. 10 illustrates another embodiment of the applicator insert 53b that may be used in conjunction with the instrument illustrated in FIG. 7. In the illustrated embodiment, the applicator insert 53b comprises an elongated magnetostrictive acoustic member 93b formed of a plurality of thin sheets of a magnetostrictive material such as permendur or permendur, or any other material capable of mechanically elongating when subjected to a magnetic field. In view of the relative dimensions of the magnetostrictive portion 93b, it will be seen that upon insertion in a suitably oriented magnetic field, a significant elongation of the stack will occur. Consequently, upon elongation of a magnetostRICTIVE stack 93b by whose magnitude varies, the length of the stack 93b will similarly vary. In accordance with known principles, the magnetostrictive stack 93b is made to be of a length equal to an integral number of half wavelengths in the material at the driving frequency. In this manner, maximum conversion of energy from the magnetic field to mechanical vibration is achieved. As noted hereinabove, other forms of electrical to mechanical transducers, e.g. piezoelectric, ferrites, may also be employed in accordance with the present invention.

Rigidly affixed to one end of the magnetostrictive element 93b, such as by welding, is a connecting member 94b. This member may be formed of any suitable material capable of supporting vibrations transmitted thereto from the magnetostrictive stack and many metals and hard plastics are suitable for this purpose. However, to operate most efficiently, the connecting member 94b should be made equal in length to an integral number of half wavelengths in the material at the frequency of vibration. A suitable material enabling the length of the connecting member 94b to be maintained within reasonable limits is Merlon, but it will be understood that other materials may also be used.

Preferably, the connecting member 94b is formed to produce at its output end 95b an amplification of the longitudinal vibrations applied to its input end by the magnetostrictive member 93b. To effect this function, the member 94b is formed in two sections 96b and 97b of differing diameter. The transition from the larger to the smaller diameter occurs at a nodal point of vibration, that is, a point along a member wherein longitudinal motion is a minimum. In a uniform diameter element one-half wavelength long, such a node would occur at the quarter wave point, halfway between the ends. By locating the transition point at a nodal plane, proper acoustic impedance transformation takes place and an increased longitudinal amplitude of vibration is obtained at the output end 95b. A more complete discussion of such acoustic impedance transformers may be found in U.S. Pat. No. 24,033 granted Aug. 29, 1951 to Balmuth and Kurts for a "Vibratory Machine Tool and Vibratory Abrasion Method." The applicator member 80b is rigidly affixed to the forward end 95b of the connecting member such as by a screw-threaded fastening. By this means, longitudinal vibrations in the connecting body may be transmitted unimpeded to the applicator means 16b and consequently to the stimulant means 52b mounted therein.

Surrounding the magnetostrictive stack 93b and the connecting member 94b is a generally cylindrical casing 100b formed of a suitable nonmagnetic and fluid impervious material, such as plastic or aluminum. The casing 100b is structurally rigid and spaced from the peripheral surfaces of the stack 93b and connecting member 94b over substantially their entire lengths so as not to be vibrated therewith.

At the connecting member end of the casing 100b the walls thereof are shaped to thicken specifically to closely engage the peripheral surface of the enlarged portion 96b of the connecting member. At approximately a nodal point of longitudinal motion in the connecting member, an annular insert 101b of rubber or similar resilient material is secured in the casing and extends therearound to snugly engage a mating depression provided in the outer surface of the connecting member 94b. This serves to firmly support the connecting member within the casing 100b in such a manner that no longitudinal vibration is transmitted to the casing 100b. The insert 101b and the closeness of fit between the casing 100b and the outer surface of the connecting member 94b also provide a fluid-tight seal between the casing 100b and the connecting member 94b.

The end of the casing 100b beyond the magnetostrictive portion 93b is thickened at 102b and provided with an aperture 103b extending all the way through to receive the front lip 65b such that the liquid flowing therein enters the passageway 72b, which includes the passageway 73b, which is the space between the stack 93b and the inside of the casing 100b. The instrument passageway 72b is continued within a conduit including a transverse opening 104b which connects to a horizontal bore 105b which continues to the output end 95b of the connecting body.

At its front end, the casing 100b is provided with a smaller diameter shoulder adapted to be engaged by the applicator means 16b which, in general is cylindrical in cross section and provided with the applicator passageway 74b along its length to allow continued flow of the jet stream. The applicator insert 53b may also be formed of a plastic material of high resilience, sized so as to firmly engage the reduced diameter shoulder of the casing 100b. The applicator insert 53b need be removed only when it is desired to replace the applicator means 16b, such as when the stimulant 52b has been worn to a point where it is no longer effective.

The stimulant 52b may be formed of an annular rubber or plastic member 106b wherein the jet of liquid 15b that exists from the output surface 84c of the support member 80b is in spaced relation to the surface to be treated.

It will be seen that the entire applicator insert 53b is self-contained and includes only one part subject to wear, i.e. the stimulant 52b in the applicator support member 80b is arranged to be removed without difficulty and replaced with a new unit whenever necessary.

FIG. 11 illustrates a form of the applicator means 16c in which the jet 15c exits from the applicator member 80c at its output surface 84c in spaced relation to a tip 106c thereof by a distance D. This permits the tip 106c to engage the tooth or
gum structure and act as a stimudent, while at the same time maintaining the liquid jet force energy spaced therefrom at a preselected distance. The fixed spacing between the output surface 84c and the tip 106c is important in that the user cannot bring the output surface 84c so close to the treated surface as to possibly “damp” out the jet stream forces by flooding a discrete area being treated.

FIG. 12 illustrates a form of the applicator means 16d similar to that disclosed in FIG. 11 except that stimudent means 52d in the form of individual bristles are provided such that the jet 15d similarly exits from the applicator means 16d in spaced relation to the engaged surface.

From the foregoing, it will be evident that the application of ultrasonic energy by employing micropulsed energy waves to tooth and gingival surfaces is effective to provide significantly improved cleaning action, and, if employed for regular dental care in the home, will result in maintenance of greater dental health than is possible utilizing conventional tooth brushing implements.

While the invention has been described in connection with particular ultrasonic motor and applicator constructions, various other devices and methods of practicing the invention will occur to those skilled in the art. Therefore, it is not desired that the invention be limited to the specific details illustrated and described and it is intended by the appended claims to cover all modifications which fall within the spirit and scope of the invention.

I claim:

1. The method of treating the gingival and tooth structures of the oral cavity for hygienic control thereof, with an applicator adapted to be inserted within the oral cavity, comprising the steps of:
   A. inserting said applicator within the oral cavity;
   B. generating a stream of liquid of small cross-sectional area;
   C. pumping said stream of liquid through said applicator;
   D. micropulsing said stream of liquid in said applicator to induce therein energy waves in the ultrasonic frequency range;
   E. moving said applicator to direct said stream of liquid within said oral cavity to substantially engage the tooth or gingival structures thereof;
   F. microstimulating said engaged structures by transmitting said ultrasonically micropulsed energy waves contained in said stream to effect the treatment thereof, whereby a level of hygienic control may be hygienic control may be maintained in said oral cavity, and
   G. pulsing said stream at a frequency below that of said micropulsing frequency to provide doses of mechanical energy at two different frequencies to said treated structures.

2. The method of treating the oral cavity as claimed in claim 1, wherein said micropulsing is obtained by superimposing on said stream of liquid high frequency mechanical vibrations in the frequency range of 5,000 cycles per second to 1,000,000 cycles per second.

3. The method of treating the oral cavity, as claimed in claim 2, wherein said frequency of micropulsing is preferably in the range of 16,000 cycles per second to 40,000 cycles per second.

4. The method of treating the oral cavity, as claimed in claim 1, wherein the cross-sectional area of said stream in energy treatment relationship to said structure is in the diametrical range of 0.010 inch to about 0.070 inch.

5. The method of treating the oral cavity, as claimed in claim 1, wherein the frequency of pulsing said stream is in the range of 6 cycles per minute to 26,000 cycles per minute to obtain a macropulsing thereof, whereby said macropulsed energy is transmitted to said selected structure.

6. The method of treating the oral cavity, as claimed in claim 1, wherein the frequency of pulsing said stream is in the ultrasonic frequency range.

7. The method of treating the oral cavity, as claimed in claim 1, wherein:
   a. said stream of liquid is moved to substantially engage said gingival structure; and
   b. said microstimulating includes micromassaging of the cellular structure of said gingival structure by said ultrasonically micropulsed energy waves in said stream pervasively penetrating and treating the accessible inner region of said gingival structure for treatment thereof.

8. The method of treating oral cavity, as claimed in claim 1, wherein:
   a. said stream of liquid is moved to substantially engage said tooth structure and any foreign substances adhered thereto; and
   b. said microstimulating includes a microfatiguing of said foreign substances by transmitting said micropulsed energy waves contained in said stream against said tooth structure for a period of time sufficient to fatigue the bond therebetween and effect the removal of said foreign substances therefrom, whereby the tooth structure may be maintained substantially free of foreign substances.

9. The method of treating the oral cavity, as claimed in claim 1, wherein:
   a. said stream of liquid is moved to simultaneously engage said tooth and gingival structures; and
   b. said microstimulating simultaneously effects a micromassaging of said gingival structure and a microfatigue of said tooth structure to remove surface, interproximal and gum line foreign substances therefrom, whereby the hygienic condition of said oral cavity is maintained.

10. The method of treating the gingival and tooth structures of the oral cavity for hygienic control thereof, with an applicator adapted to be inserted within the oral cavity, comprising the steps of:
   A. inserting said applicator within the oral cavity;
   B. generating a stream of liquid of small cross-sectional area;
   C. pumping said stream of liquid through said applicator;
   D. micropulsing said stream of liquid in said applicator to induce therein energy waves in the ultrasonic frequency range;
   E. moving said applicator to direct said stream of liquid within said oral cavity to substantially engage the tooth or gingival structures thereof;
   F. microstimulating said engaged structures by transmitting said ultrasonically micropulsed energy waves contained in said stream to effect the treatment thereof, whereby a level of hygienic control may be maintained in said oral cavity, and
   G. simultaneously transmitting to the selected structure mechanical vibratory energy in the ultrasonic frequency range by means of said applicant inserted within the oral cavity and directly placed in energy transmission relationship to said structure, whereby said microstimulation is obtained by transmitting ultrasonic energy to the selected structure through substantially direct engagement of said applicator and through the liquid medium of said stream applied at a selected velocity.

11. The method of treating the oral cavity, as claimed in claim 10, wherein said applicator includes at least one stimudent element adapted to engage said structure.

12. The method of treating the oral cavity, as claimed in claim 11, wherein said stream of liquid and stimudent are in closely spaced relation to each other for simultaneous engagement of the area of the structure under treatment.

13. The method of treating the gingival and tooth structures for therapeutic purposes with an applicator adapted to be inserted within the oral cavity, comprising the steps of:
   A. inserting said applicator within the oral cavity;
   B. vibrating said applicator in the ultrasonic frequency range for generating elastic energy waves;
   C. pumping a jet of liquid through said applicator;
   D. micropulsing said jet of liquid to induce therein elastic energy waves in the ultrasonic frequency range;
E. selecting said ultrasonic frequency ranges for said applicator and jet, compatible with the portion of the structure to be treated;
F. microstimulating the portion of the engaged structure being treated by transmitting the combined elastic energy waves of said applicator and jet stream thereto, and by manually moving said applicator across the surfaces of the structures to be treated; and
G. pulsing said jet in a preselected pattern of pulses at spaced intervals of time to provide successive doses of said elastic energy waves to said treated structure.

14. The method of treating the gingival and tooth structures, as claimed in claim 13, further including the step of maintaining said jet exiting from said applicator, in spaced relation to said treated structure.

15. The method of treating the gingival and tooth structures, as claimed in claim 13, wherein said elastic energy waves of said micropulsed jet of liquid is induced therein as said jet is pumped through said applicator.

16. The method of treating the gingival and tooth structures, as claimed in claim 13, wherein said micropulsed energy waves induced by said apparatus cause vibrational or vibratory action within said structures.

17. The method of treating the gingival and tooth structures, as claimed in claim 13, wherein said micropulsed energy waves, as described in claim 16, are transmitted through said coupling means which are adapted to be interchanged therewith.

18. A system as claimed in claim 19, wherein said motor means includes:
   a. coil means in axial spaced relation to said acoustic element for creating an alternating magnetic field at the frequency of alternating current signals applied thereto;
   b. said acoustic element including an elongated tubular member forming said passageway extending therethrough; and
   c. a plurality of spaced-apart strips of magnetostriuctive material extending axially along said tubular member and secured thereto, said strips being disposed in said magnetic field, whereby upon application of alternating current signals to said coil said elongated member mechanically vibrates in a longitudinal direction and vibrations are induced in said liquid stream within said passageway.

20. A system as claimed in claim 23, wherein said acoustic element and said coupled applicator means are adapted to be removably secured to said motor means for interchangeability therewith.

23. A system as claimed in claim 19, wherein said motor means includes:
   a. coil means in axial spaced relation to said acoustic element for creating an alternating magnetic field at the frequency of alternating current signals applied thereto;
   b. said acoustic element including an elongated tubular member forming said passageway extending therethrough; and
   c. a plurality of spaced-apart strips of magnetostriuctive material extending axially along said tubular member and secured thereto, said strips being disposed in said magnetic field, whereby upon application of alternating current signals to said coil said elongated member mechanically vibrates in a longitudinal direction and vibrations are induced in said liquid stream within said passageway.

24. A system as claimed in claim 23, wherein said acoustic element and said coupled applicator means are adapted to be removably secured to said motor means for interchangeability therewith.

25. A system as claimed in claim 19, wherein:
   a. said applicator passageway terminates in at least one aperture on said output surface; and
   b. stimulent means extending from said output surface in spaced relation to said aperture, whereby treatment may be obtained by the combined effects of said liquid stream and vibrated stimulent means.

26. A system as claimed in claim 25, wherein:
   a. said passageway terminates in a plurality of spaced-apart apertures through which said micropulsed liquid flows; and
   b. said stimulent includes a plurality of bristle clusters with said respective apertures in spaced relation thereto.

27. A system for use in treating the tooth and gingival structures for personal dental hygiene care, comprising:
   A. means for producing a stream of liquid;
   B. means for forming a passageway to transmit said stream of liquid, said means for forming a passageway includes a hand held instrument containing said passageway through which said stream of liquid passes;
   C. means for superimposing on said stream of liquid mechanical vibrations in the ultrasonic range to form micropulsed energy waves therein, for treatment of said structures, said means for superimposing on said stream said micropulsed energy waves, includes motor means contained within said hand-held instrument for converting electrical energy into mechanical vibrations at an ultrasonic rate for vibrating an acoustic element contained therein, said acoustic element positioned in energy transferring relationship to said passageway, wherein said ultrasonic mechanical vibrations are transmitted to said stream of liquid as it passes therethrough.
   D. means in communication with said passageway for applying said stream of liquid to said structures, said means for applying said stream of liquid to said structures, includes applicator means adapted to be moved freely relative to the tooth and gingival structures and having an applicator passageway extending therethrough and terminating at an output surface, said applicator passageway in communication with said instrument passageway, whereby said micropulsed liquid stream may pass therethrough for engagement with said structures, and
   E. means for coupling said applicator means to said motor means to vibrate said applicator means at an ultrasonic rate, whereby said mechanical vibrations of said applicator means is adapted to be transmitted to said treated structures.

20. A system as in claim 19, further including means for pulsing said energy waves to obtain a rest period between successive doses of energy.

21. A system as in claim 20, wherein said rest period is obtained by pulsing said stream at a frequency less than the frequency of said micropulsed energy waves.

22. A system as in claim 20, wherein said rest period is obtained by pulsing said energy waves at a frequency in the ultrasonic range.
c. a casing in spaced relation to said magnetostrictive portion and sealed at one end in surrounding relation to said connecting member and open at its opposite end in communication with said means producing said stream of liquid, the spacing between said casing and acoustic element forming said instrument passageway.

29. A system for use in treating the tooth and gingival structures of the oral cavity for personal dental hygienic care, comprising:

A. reservoir means for retaining a supply of liquid;
B. pumping means in communication with said reservoir means for continuously supplying liquid therefrom, said pumping means adapted to form a jet of liquid;
C. instrument means adapted to be hand-held by the user and in communication with said pumping means for receiving said jet stream which is adapted to pass through an instrument passageway extending therethrough;
D. motor means contained within said instrument means for converting electrical energy into mechanical vibrations at an ultrasonic rate, said motor means in energy transmission relationship to said jet stream within said instrument passageway to impart thereto micropulsed energy waves for treatment of said structures; and
E. applicator means extending from one end of said instrument means for movement freely within the oral cavity, and having an applicator passageway extending therethrough in communication with said instrument passageway, and terminating in a single nozzle, said jet stream passing through said applicator and forming a single nozzle jet stream for transmitting said energy waves to said treated structures. Ultrasonic rates, whereby said mechanical vibrations of said applicator means is adapted to be transmitted to said treated structure.

30. A system as in claim 29, further including means for coupling said applicator means to said motor means to vibrate said applicator means at ultrasonic rates, whereby said mechanical vibrations of said applicator means is adapted to be transmitted to said treated structures.

31. A system as in claim 29, wherein said pumping means is adapted to pulse said jet stream within a defined frequency range.