

[54] **ULTRASONIC REPLACEABLE SHAVING HEAD AND RAZOR**

3,509,626 5/1970 Mead 30/45
3,610,080 10/1971 Kuris..... 30/45 X

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FOREIGN PATENTS OR APPLICATIONS

929,363 12/1947 France..... 30/45

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[22] Filed: **Dec. 3, 1971**

[21] Appl. No.: **204,632**

[57] **ABSTRACT**

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[51] Int. Cl..... **H01v 7/00, B26b 21/00**

[58] Field of Search **30/45, 272 A; 310/8.2, 8.3**

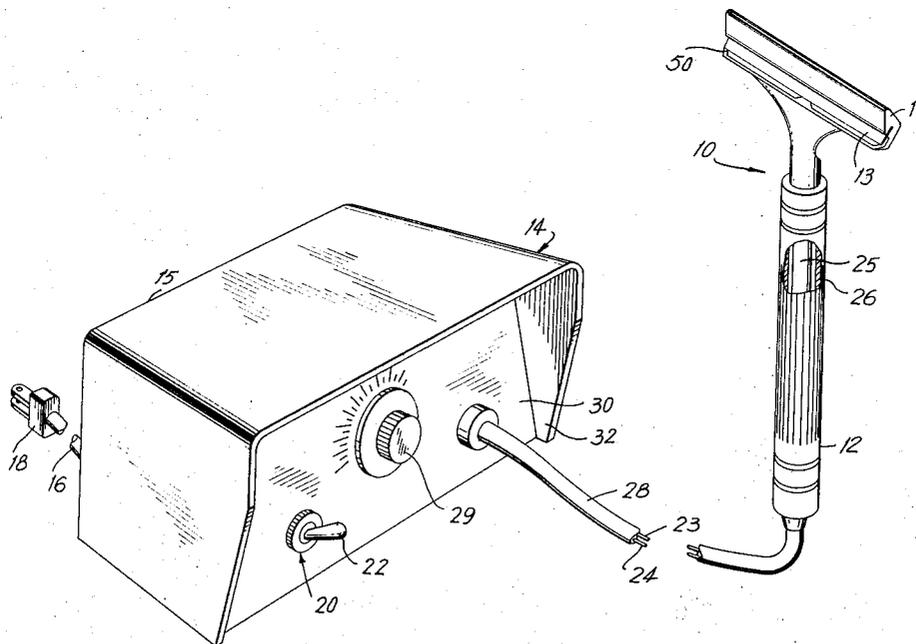
A shaving head for use, in combination with a handle containing an ultrasonic motor, said head including a blade disposed therein and mounted therein in a manner to be ultrasonically vibrated with the head detachably and rigidly coupled to the ultrasonic motor.

[56] **References Cited**

UNITED STATES PATENTS

2,721,382 10/1955 Beauchaine..... 30/45

58 Claims, 24 Drawing Figures



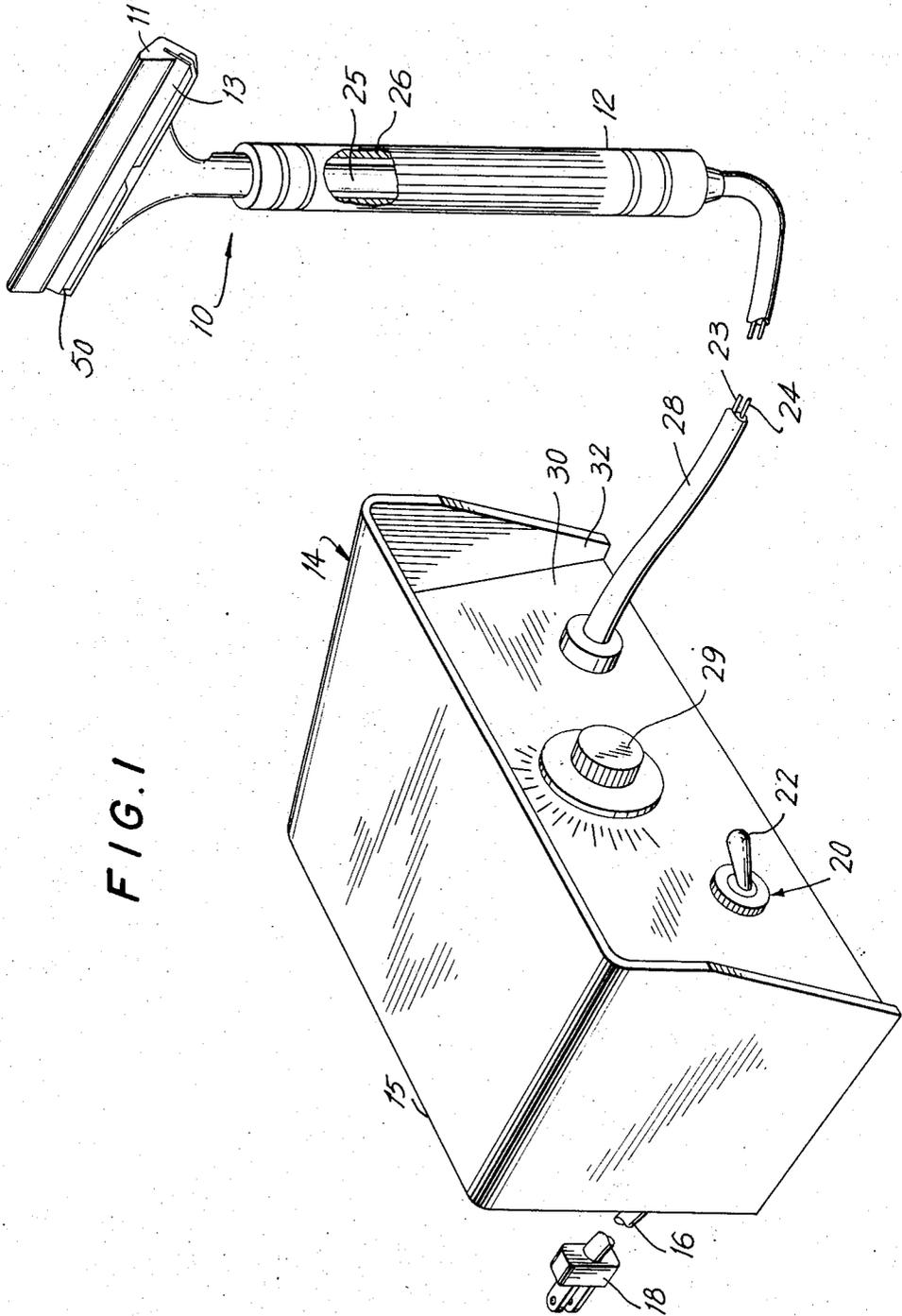


FIG. 1

FIG. II

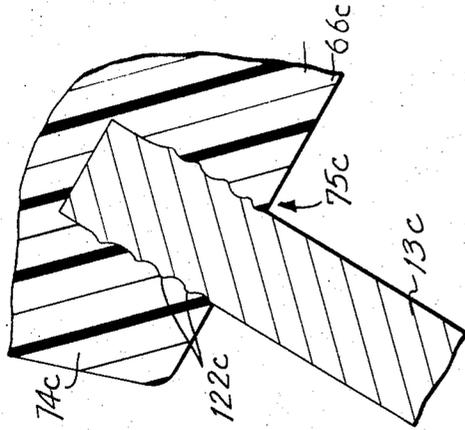


FIG. 9

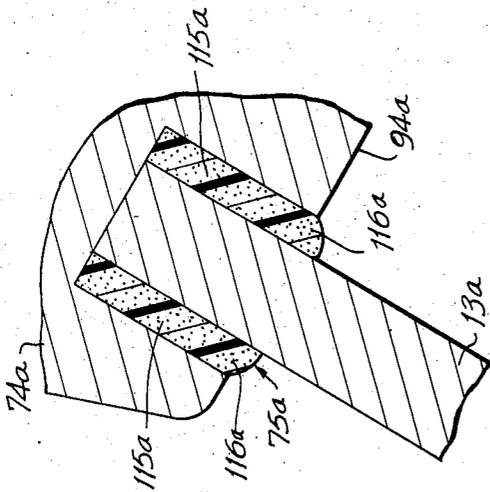


FIG. 10

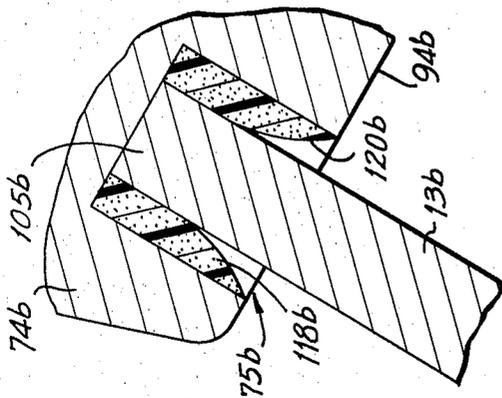
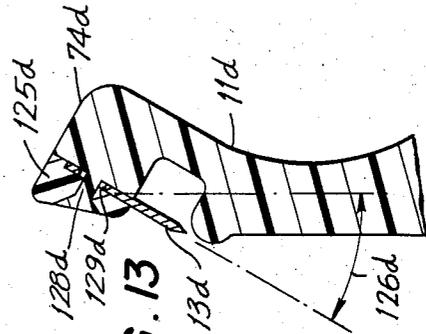


FIG. 13



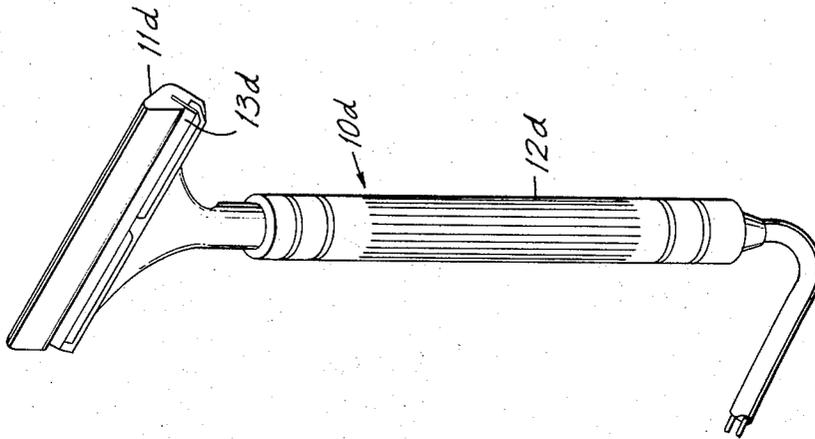
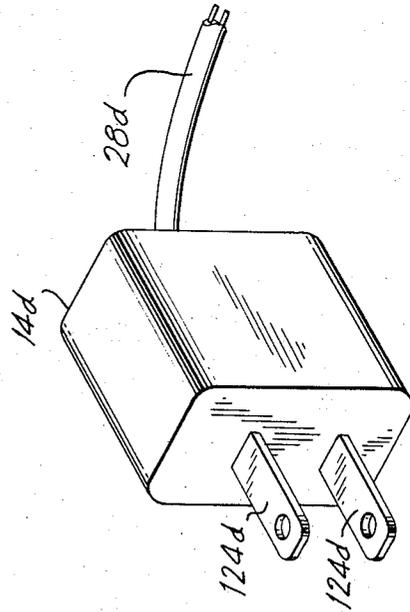


FIG. 12



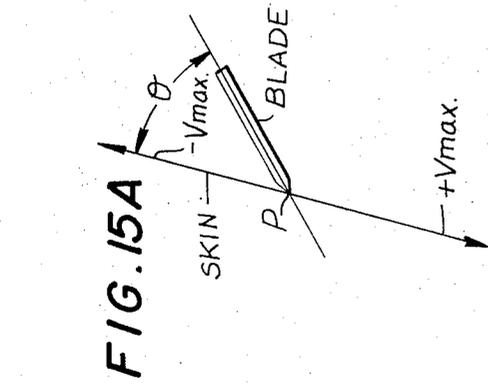


FIG. 15A

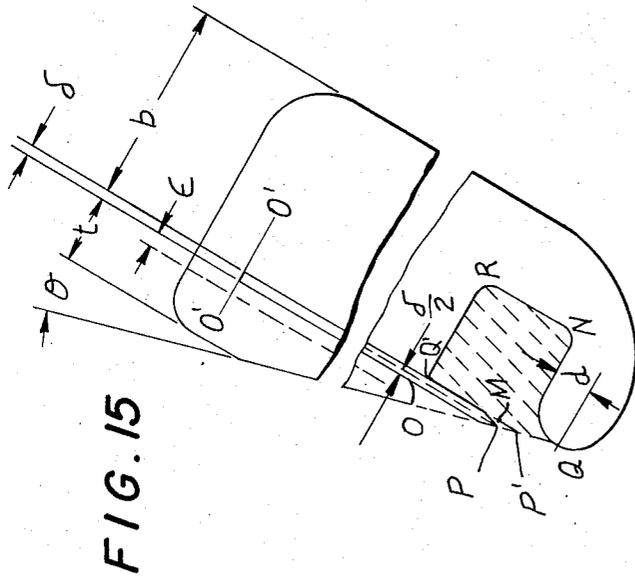


FIG. 15

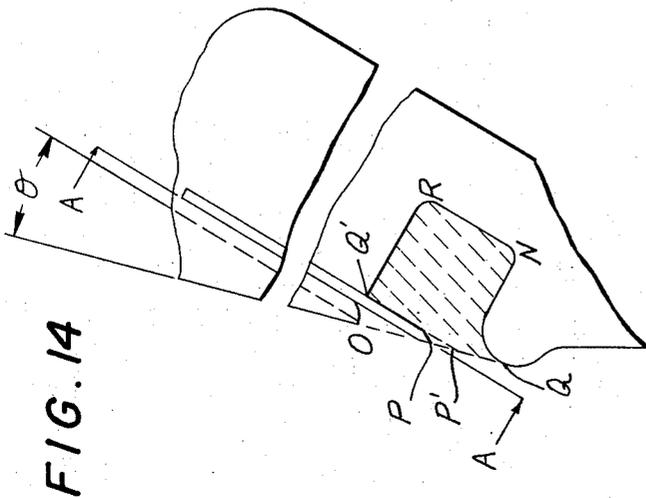


FIG. 14

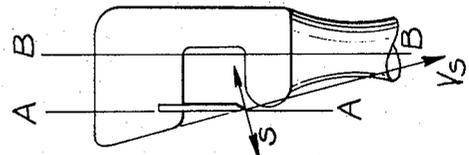


FIG. 17

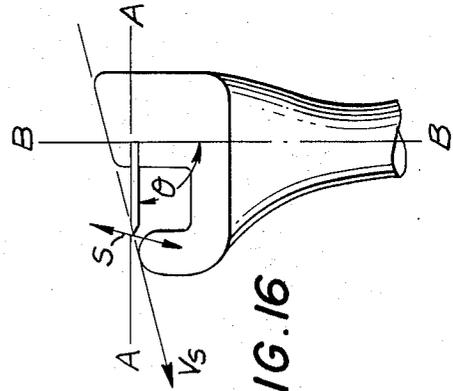


FIG. 16

FIG. 16A

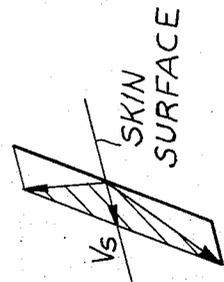


FIG. 18

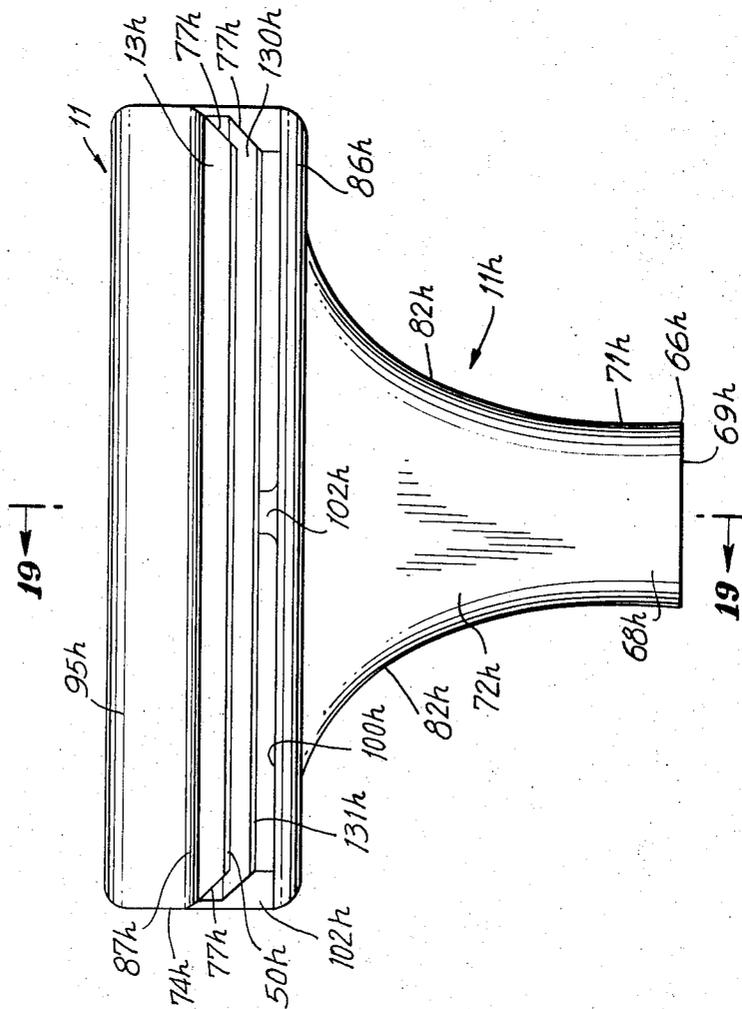
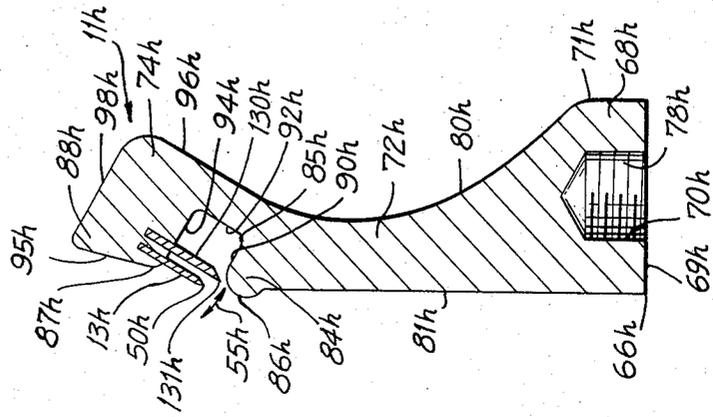


FIG. 19



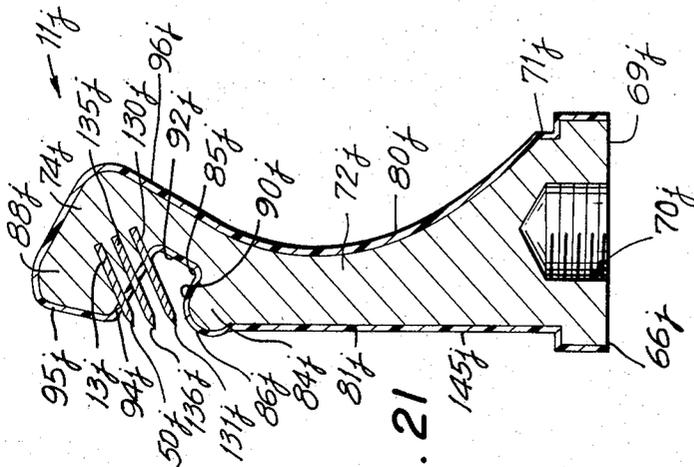


FIG. 21

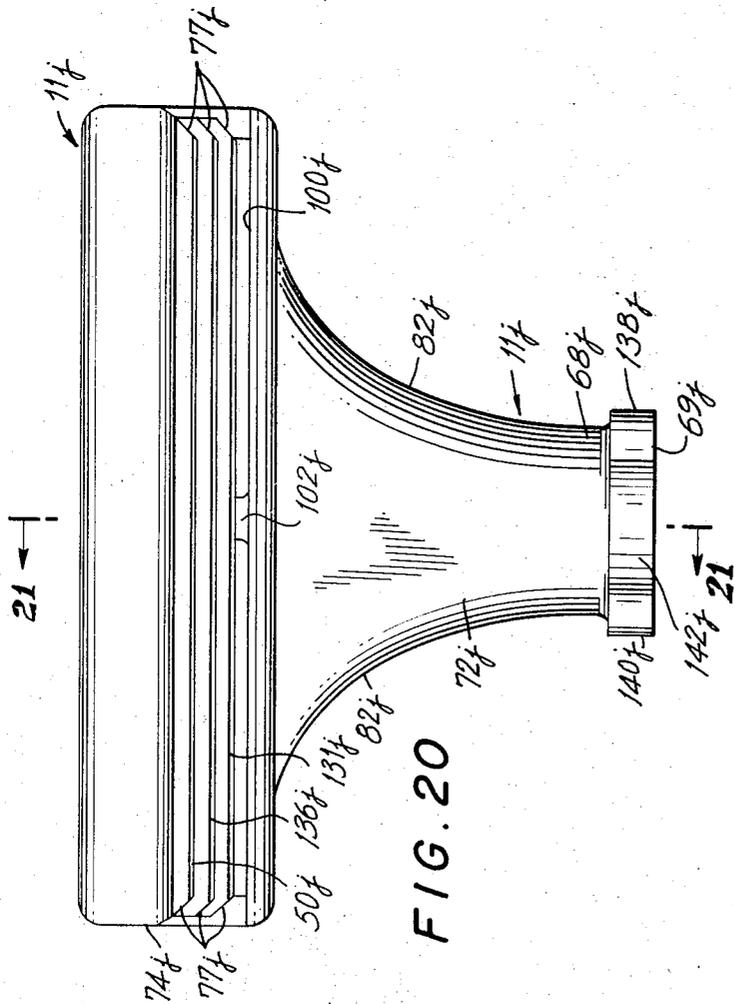


FIG. 20

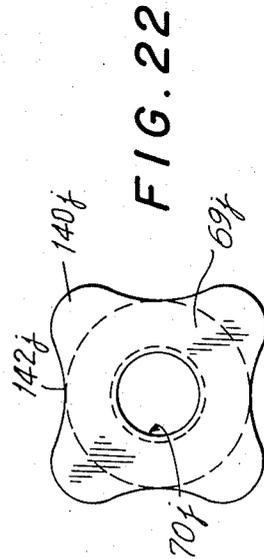


FIG. 22

ULTRASONIC REPLACEABLE SHAVING HEAD AND RAZOR

BACKGROUND OF THE INVENTION

The field of the present invention is that of safety razors, and, more particularly, that of a replaceable shaving head suitable for an ultrasonic electric razor.

The field of the invention is also that of razor blade head adapted to be held in a handle or other manipulating means, which when assembled with ultrasonic means, forms a razor unit.

More particularly, the field of the invention is that of safety razors and safety razor blade assembly in which the assembly includes a single or double edge blade, and in which the sharpened edge is exposed with the unsharpened edge contained in the housing units made according to the present invention are easily fastened to a razor handle to form an ultrasonic razor unit, and are manufactured economically so that the units may be thrown away after use.

The use of ultrasonic energy has been proposed for shaving in which a razor blade is ultrasonically vibrated for engagement with and cutting the hairs in a "wet" type shaving instrument as exemplified in U.S. Pat. Nos. 3,509,626 and 3,610,080, the latter patent is assigned to the assignee of the present invention and one of the present inventors is the inventor thereof.

The inventors of the present invention have now discovered that a disposable or replaceable shaving head may be used in an ultrasonic razor to enhance its effectiveness in various ways as hereinafter explained in detail.

OBJECTS OF THE INVENTION

An object of this invention to provide a readily replaceable novel shaving head which shall be particularly adapted to be driven in the ultrasonic frequency range for regular personal hygienic care to remove hair from the body in shaving.

Another object of the present invention is to provide a novel shaving head which is coupled to an ultrasonic vibratory hand-held instrument and capable of withstanding use for prolonged periods of time without the blade element of the head fatiguing.

Another object of the present invention is to provide an ultrasonic head having a base with a blade secured thereto and which blade vibrates at substantially the same frequency of vibration as the base for comparatively long periods of time without fatiguing.

Another object of the present invention is to provide a novel head for use with a shaving implement that is readily replaceable.

Another object of the present invention is to provide a shaving head having a body with a blade extending therefrom which is designed to flexurally vibrate at its free end.

Another object of the present invention is to provide an ultrasonic shaving head in which the blade extending from the body projects outwardly to engage the skin.

SUMMARY OF THE INVENTION

These and other objects of the invention which will become hereafter apparent are achieved by a readily replaceable shaving head of an acoustically unitary construction having a body portion adapted to be con-

nected to an ultrasonically vibrated driving member or ultrasonic motor that may be hand-held and the shaving base is fixed to said driving member substantially in the region of high frequency vibration, for example, at or near a loop of longitudinal, torsional, or radial vibration. In this manner the blade holder is vibrated at a frequency and amplitude which substantially corresponds to the frequency and amplitude of vibrations of the driving member to which said body is secured. The means for coupling the blade or other shaving elements to the head portion, as well as the length diameter and composition of the body member all play an interrelated role on the fatigue life of the blade.

The shaving head acts as a wave guide to distribute the vibrational energy in a pre-determined fashion to the blade element contained within the unitary construction. To accomplish this task the shaving head is designed to comply with certain acoustical design principles requiring the application of acoustic wave guide characteristics.

The construction of the shaving head is such that the total acoustical system constituting said razor with respect to its longitudinal dimensions is at least a 180° shift in phase from the blade output section to the razor free end or the razor.

In the illustrated preferred embodiments of the invention, as will be hereafter more fully described, coupling means are provided to firmly secure one end of the blade to the head of the body whereby vibratory motion is imparted to the blade. To receive the blade a groove or channel which extends substantially across the face surface of the head is provided for receiving an end of the blade. A bonding agent in the form of an epoxy cement couples the base of the blade so that a proper transmission of the high frequency mechanical vibrations induced in the base is transmitted to the blade while maintaining a flexural component of motion.

A feature of the invention resides in the arrangement of the bonding agent within the aperture in surrounding relation to the terminal end of the blade so that a maximum amount of energy is transmitted with a minimal loss in the form of heat to the blade. In one form of coupling a recessed area between the blade and aperture exists. The recessed area is provided with gradually tapering upwardly formed surface which merges with the face of the head from which the blade extends. It is believed that the curved sloping form of the bonding agent, generally having a given radius tends to control the movement of the blade when it is in contact with the skin whereby the stress at the juncture of base and blade is maintained at a minimum. Thus, the form of the bonding agent acts to limit the movement of the blade at its free end, thereby maintaining the juncture of blade and bonding agent within a defined stress limit.

Another feature of the invention resides in the provision of means for acoustically insulating the base of the head when used as a part of a shaving implement. This acoustically insulating layer may be of closed cell rubber or other vibratory absorbing material for it minimizes any audible sounds that are produced at or in the vicinity of the head and would normally be transmitted therethrough. The layer of acoustically insulating material may be coated with a smooth textured material which may be of a variety of colors and generally of a thermoplastic material for identification purposes as well as additional insulation.

Still another feature of the present invention is the arrangement and interrelationship of blade to obtain maximum shaving.

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 perspective view of an ultrasonic shaving unit in accordance with the present invention;

FIG. 2, is a front view of the ultrasonic shaving unit in accordance with the present invention;

FIG. 3, is a side view of the ultrasonic shaving unit in accordance with the present invention;

FIG. 4, is an enlarged front plan view of the shaving head of the present invention;

FIG. 5, is an enlarged sectional view taken along line 5—5 of FIG. 2;

FIG. 6, is an enlarged sectional view taken along line 6—6 of FIG. 2;

FIG. 7, is an enlarged end view taken along line 7—7 of FIG. 2;

FIG. 8, is an enlarged sectional view corresponding to a portion of FIG. 5 illustrating the position of the blade within the body portion with coupling means for securing it thereto;

FIGS. 9 and 10 are views similar to that of FIG. 8 but illustrating the manner in which the coupling means in the form of a bonding agent may vary in configuration in accordance with this invention;

FIG. 11, is a view similar to FIG. 8 illustrating another form of coupling means;

FIG. 12, is a view similar to FIG. 1 illustrating another form of the present invention;

FIG. 13, is a partial enlarged view in cross-section of the assembled shaving head;

FIGS. 14, 15, 15A and 16A are enlarged fragmentary sections helpful in explaining the operation of the present invention;

FIGS. 16 and 17 are partial views of shaving heads showing different angular positions of the blade therein;

FIG. 18, is an enlarged plan view of a shaving head having two blades;

FIG. 19, is a sectional view taken along line 19—19 of FIG. 18;

FIG. 20, is an enlarged plan view of a shaving head embodiment having three blades, gripping means, and also being acoustically insulated;

FIG. 21, is a sectional view taken along line 21—21 of FIG. 20;

FIG. 22, is a partial bottom view of the shaving head of FIG. 20.

DETAILED DESCRIPTION OF THE INVENTION

Turning now to FIGS. 1, 2 and 3, there is illustrated a shaving unit 10, which will be described in greater detail hereinafter, and for present purposes it is sufficient to indicate that it includes an instrument means or handle means 12 adapted to be held by the user in a conventional manner, with a detachable shaving head or assembly 11 containing a member or blade 13 to be ul-

trasonically vibrated and mounted therein. Extending from one end thereof is supply means 14 which supplies to the instrument means 12, power from generator or power means 15 having an electrical cord 16 connected to a plug 18 adapted to be plugged into a standard electrical outlet, i.e., 60 cycles per second. Switching means 20 on the generator 15 includes a switch 22 for providing power for energizing the ultrasonic transducer or motor 25 contained within the instrument casing or housing means 26 of the hand held instrument 12. The energy from the generator 15 is transmitted to the ultrasonic motor by wires 23 and 24 extending through the flexible conduit 28 of the supply means 14. The power transmitted by the generator 15 to the instrument 12 may be varied by control knob 29 extending beyond the front panel 30 of the cabinet 32. The power control knob 29 is adjusted by the user of the unit to adjust to his hair growth or beard and particular needs. For example, if the individual has a light beard or hair growth than a lower power setting might be selected, and if it is a heavy beard or hair growth then a larger power setting may be selected. Obviously, the unit 10 is for use by both males and females.

The complete assembly for use in the home includes the generating means 15, for example, a transistorized oscillator capable of producing electrical oscillation at a frequency in the ultrasonic range, defined herein to include vibrations in the range of 5,000 to 1,000,000 cycles per second, but generally between 16,000 and 100,000 cycles per second. Various types of such oscillators are known and it is not believed necessary to describe the details herein. In practice, the generator 15 may be as small as 1 or 4 watts and generally in the range of 1 to 10 watts, and is preferably of the solid state type. Although the oscillation generator 15 may be manually tuned to the resonant frequency of the mechanically vibrating unit, it is desired to employ an oscillation generator, as described above, which automatically adjusts to the resonant frequency by reason of the changes occurring in the latter as the shaving member 13 is driven and engages the hairs of the human being shaved. Such changes in the resonant frequency of the mechanically vibrating unit occur by reason of the fact that the natural frequency of the blade 13 will vary with the load placed upon it which might be water, shaving cream or physical engagement with hairs.

The ultrasonic energy available at the cutting edge 50 of the blade 13 provides several beneficial results. It has been found that, by reason of the vibrations at the cutting edge 50, which vibrations may be in a substantially vertical plane, that is, in a plane perpendicular to the plane of the cutting edge 50, the resistance of the blade member 13 across the skin surface is very substantially reduced. The friction reduction effects and the cutting ease may be obtained by the vibrations having an elliptical, orbital, longitudinal or flexural component of motion at the cutting edge 50. A possible explanation of this observed phenomenon is that the extremely high acceleration of the cutting edge 50 of shaving member 13 resulting from the vibrations causes only a relatively small sliding friction to be present between the engaged skin surface and the shaving member 13. Thus, even though the shaving member 13 is essentially stationary with no gross movement the acceleration forces not only reduce the friction but successively subject the hair portions extending from the skin to the cutting action of the cutting edge at a repetition

rate of from 5,000 to 1,000,000 times per second and thus provide a continuous severing of the hairs at or adjacent to the surface of the skin.

The frequency of the vibrations at the free end portion of blade member 13 may be in the range from 5,000 cycles per second to 1,000,000 cycles per second, and preferably in the range from 16 to 100 kilocycles per second, while the amplitude of the vibrations is selected within the range from approximately 0.0001 to 0.025 inch so as to ensure the introduction of vibratory energy sufficient to perform the cutting of the hair particles and maintain the friction reduction qualities.

Thus, the vibratory energy applied at a suitable frequency, to the blade produces vibratory motion of the molecular structure of such blade so that the surface of blade 13 is continuously maintained at a state of motion relative to the surface of the skin, whereby the frictional resistance of movement of the shaving member 13 to the surface is determined by the kinetic coefficient of friction therebetween rather than by the substantially larger static coefficient of friction between the material of the shaving member 13 and the skin. The ultrasonic shaving instrument 10 also permits a closer shave to be obtained due to the inherent characteristics of a vibratory member which when vibrated in the ultrasonic frequency range as herein defined will vibrate with an acceleration of at least 1,000g's such that the time of contact between the cutting edge 50 and the surface of the skin is minimal even when a static force is applied by the user against the skin. As seen in FIG. 5 the blade 13 at the cutting edge 50 has a flexural component of motion indicated by the double headed arrow 55.

FIG. 4 shows a front view of the removable shaving head 11 and FIG. 5 is an enlarged view of the front end of the handle means 12 having mounted therein the ultrasonic motor 25 which includes a transmission member 35 having a rear end 36 and front end 38 in axial spaced relation to each other. The ultrasonic motor 25 includes a transducer 40 extending in telescopic relation to the axial bore 42 of the housing means 26.

The transducer 40 may be one of a variety of electromechanical types, such as electrodynamic, piezoelectric and magnetostrictive. The transducer in the ultrasonic motor 25 is longitudinally dimensioned so as to have lengths which are whole multiples of half-wavelengths of the compressional waves established therein at the frequency of the alternating current supplied so that longitudinal motion as indicated by arrow 65, occur substantially at the end 38 of the motor 25.

The transmission member 35 may be of circular cross-section having an outer diameter 44 adapted to extend within the bore 42 with supporting means 45 extending between the transmission member 35 and housing means 26 which may be in the form of one or more spaced apart o-rings 46 such that the vibratory energy obtained therein is not transmitted to the housing wall 48 and in turn the instrument 12 when held by the user. By this means, longitudinal vibrations in the transmission or connecting body 36 may be transmitted unimpeded to the shaving head 11 and in turn the blade 13 and consequently to the edge 50 thereof. One or more peripheral grooves 52 is provided on section 35 that may be near the nodal point of the transducer for the o-ring 46 which extends within the accommodating recess 54 provided in the inner wall surface 42 of the walls 48. Due to the poor sonic transmission qualities

of the resilient o-ring which may be made of rubber, and its location there is negligible energy coupling to the housing means 26 and the acoustic element 25 is acoustically isolated from the instrument.

The transmission member 35 may have a front end portion 56 terminating in the rear end 36. The front end 56 is illustrated as having a reduced cross sectional area, which may be circular, as defined by the axial wall 60 which extends through the opening 62 at the front end 64 of the housing wall 48. The opening 62 may have a smaller diameter than the cavity 42. The transmission member 35 may have various shapes from its front end 38 to its rear end 36 and made from a plastic, metallic or other material capable of transmitting ultrasonic vibrations and may also act as an acoustical impedance transformer to increase the amplitude of mechanical vibration from the rear surface 36 to the front surface 38 as is well known in the art. The housing means 26 may also be made of a plastic or metallic material.

The shaving head or assembly 11 includes a body portion or section 66 capable of supporting ultrasonic vibrations with securing means 70 to connect the shaving head 11 to the ultrasonic motor 25 and a blade 13 that is positioned in a plane having an acute angle to the general direction of vibration as indicated by the double headed arrow 65. The blade 13 is joined to the body portion 66 as by coupling means 75, as seen in FIG. 8. With further reference to FIGS. 5 through 7, it will be seen that the body portion 66 is comprised of a base portion or rear section 68 that may have a cross-sectional area to coincide at its input surface or bottom 69 with the front end 38 of the motor 25, and with a tapered neck section 72 terminating in an elongated head section 74. The body portion 66 is generally formed from a solid piece of material, generally from a plastic or metallic material, capable of supporting ultrasonic vibrations. The junction between each section may be by a radius or taper and the blade 13 provided with beveled edges 77 as seen in FIG. 4.

The base section 68 has associated therewith the securing means 70 between the shaving head 11 and motor 25 which may be of various configurations with the primary intent to transmit the vibrational energy and permit the user to quickly and easily engage and disengage the shaving head 11 from its assembled relation with the motor 25. As illustrated a threaded stud 76 extends beyond the front end 38 and is adapted to mate with a thread portion 78 provided for in the rear end 69 of the base portion 68 along the vertical axis thereof. It is appreciated that other forms of securing means may be provided to retain the shaving head in its required position.

The base section 68 has an outer peripheral surface 71, that may be circular as illustrated, or rectangular or other shape. In order to maintain the shaving head at a minimum weight and obtain maximum vibrational motion at the blade edge 50 the neck section 72 has a contoured rear surface 80, with a substantially vertical front wall 81 and spaced apart side walls 82 that each blend with the head section 74 at one end thereof and with the body portion 66 at their opposite end. The neck portion 72 may have a rectangular, circular or other cross-section.

The head section 74 is comprised on its front end or face of a lower guard or guide 84 extending the width of the shaving head 74 with a contoured outer rim 86

merging with a horizontal channel or opening 85 merging therewith and a top front section 88. The angular relationship between the blade 13 which is mounted within the tip front section 88 and the guard edge 86 is explained with reference to FIGS. 14 and 15. The groove or opening 85 has a bottom wall 90 that merges with the outer rim 86, a rear wall 92 that may be vertical or rearwardly inclined and a top or upper wall 94 connected together and the latter terminating at the face or forehead 95 of the top front section 88. The head section 74 has a curved or tapered rear wall 96 that extends from the neck wall 80 to the top wall or surface 98 is spaced apart from the wall 94 in the groove 85.

Horizontal channels 100 may be provided in spaced relation to each other through the wall portion to leave remaining ribs 102 in a substantially horizontal plane as seen in FIG. 4 with the vibrational energy coupled through the ribs 102. The blade 13 is angularly disposed with respect to the vertical axis of the motor 25 and mounted within the head section 74, in a manner to obtain the necessary flexural component of vibration therein. The wall 92 within the chamber 85 may be in parallel spaced relation to the rear head wall 96 or at some other angular relationship as selected.

Accordingly, the electric shaver shown in FIGS. 1-7 is composed of a transducer element 40, preferably piezoelectric, which is bonded to a transmission member, 35, which is threaded so as to permit the removable attachment of the blade holder transmission element 11. The blade holder element 11 is so shaped as to incorporate a razor edge 13 with the guards 86 and 87 such that this assembly has a geometry for comfortable non-vibrating wet shaving, while at the same time the transducer, through the transmission line 35 and body portion 66 causes the blade's edge 50 to perform in part, a substantial flutter motion at a preselected ultrasonic frequency. As is illustrated provision can easily be made in the design of the disposable blade holder head so as to incorporate a multiplicity of blades if desired. Additionally the whole assembly may be designed to operate automatically from an automatic frequency controlled converter at resonant frequency for which the change of phase of longitudinal vibration is 180°. At the same time as above indicated the longitudinal vibrations originating in the transducer 40, undergoes a relatively complex mode conversion in the shaver head 11. The mode conversion is accomplished in part by so forming the throat section 72, which fans out to support the blade 13 (or blades) so that shear or bending vibrations are stimulated.

When the disposable head 11 is made of a plastic (a polycarbonate compound such as Lexan for example), the the distance D may itself be sufficient to cause phase shifts of 180° or more in said distance D. This is true because a plastic such as polycarbonate has a speed of elastic longitudinal vibrations which is about one tenth the speed of sound in a metal such as steel or dural. At 50 KHz, a 180° phase shift in a thin bar of polycarbonate will take place in about a quarter inch compared with two inches for steel. This low speed of sound in polycarbonate provides the unexpected advantage of causing the removable plastic head, holding the blade, to vibrate at resonance in a higher harmonic than the fundamental for the complex bending modes which are possible. In consequence, it is readily possible to produce a relatively uniform response along the

blade edge, where the flutter component is needed to realize the benefits of ultrasonic shaving. Nevertheless, even when the blade holding head is made of a metal such as dural, it has been found quite possible to obtain suitable flutter motions along the entire blade edge. In any event, it should be clear, that although the final design is essentially very simple, nevertheless the ultrasonic electric shaver disclosed herein operates satisfactorily due to the cooperation of a number of factors, including ultrasonic motion design consideration, which are compatible with small size hand held razor design which incorporates sound mechanical and in part wet shaving design elements. It is only as a result of this unique combination of factors that it has been possible to create the extremely simple ultrasonic razor herein disclosed.

As illustrated in FIG. 8, which is an enlarged view illustrating the relationship between the blade 13 and the blade seat or aperture 104 provided in the top front section 88 extending inwardly from the wall 94. Coupling means 75 as seen in FIG. 8, is such that the blade 13 has a terminal end 105 that may engage the back surface 106. The blade aperture 104 has spaced apart walls 108 and 110 in spaced relation to each other, as for example parallel to each other, that is of a greater width than the thickness of the blade 13 between the opposing surfaces 112 and 114. The blade 13 is shown angularly disposed with respect to the direction of vibration indicated by the double headed arrow 65 so that the flexural vibrations are induced in said free end 50. The extent to which the blade 13 is sloped may vary and it has generally been found that an angle of from 15° to 90° with the extended line of vibratory motion is most satisfactory. The blade 13 is embedded or cast within the bonding agent 115 to guarantee a sufficient coupling of the vibratory energy. A depth of insertion within the bonding agent may be in the range of 0.02 to 0.50 inch for blades ranging in thickness from 0.001 to 0.10. For the mounting arrangement as seen in FIG. 8 the blade thickness that has been used is 0.003 inches and the depth of insertion within the epoxy material is 0.050 inches to obtain the flexural component of motion as illustrated by the phantom lines on FIG. 8. It is essential that the bonding agent for coupling the vibrations in said head portion 88 to said blade 13 substantially occupies the entire area defined by the aperture 104 to properly transmit the vibrations. As seen in FIG. 8 this is accomplished by the bonding agent entirely occupying the aperture 104 and firmly supporting the terminal end 105 of the blade 13. The bonding agent 105 terminates substantially flush with the surface 94 of the head portion 88 from which the blade 13 extends.

FIG. 9 is essentially as shown in FIG. 8 except that the coupling means 75a consists of a bonding agent 115a in surrounding relationship to the blade 13a that terminates in a raised portion 116a which is substantially above the face surface 94a of said head portion 74a from which the blade 13a extends. The thickness of the bonding agent may be in the range of 0.0005 to 0.060 inch.

Although the bonding agent has been illustrated in FIGS. 8 and 9, as being substantially flush with or terminating in a raised portion with respect to the face surface of the blade head, it is also possible for the blade to terminate in a pre-determined configuration as illustrated in FIG. 10.

As illustrated in FIG. 10, the configuration is essentially one in which in the coupling means 75b there is a depressed area 118b in surrounding relation to the terminal end 105b of the blade 13b. This depressed area is preferably below the front surface 94b of said head portion 74b and is one having a convex surface 120b terminating near the terminal end 105b of the blade 135. Essentially this convex surface should minimize the stress concentration during the flexural movement of the free end of the blade when the latter is in contact with the skin. The contoured surface 120b, which may have a definite radius, may limit the movements of the blade element 13b.

FIG. 11 illustrates a form of coupling means 75c which permits vibrational energy of a pre-determined fashion to be transmitted to the blade 13c. The shaving body portion 66c may be of a thermoplastic material as is bonded or secured to the surface irregularities 122c when the head portion 74a is formed. This for example can take place when the blade 13c is positioned and held in place and the body portion 66c injection molded in place therearound. In this manner an intimate bond is obtained to retain the blade in fixed position and simultaneously permit the transmission of the mechanical vibrations therethrough.

FIG. 12 illustrates a shaving unit 10d including instrument means 12d with a detachable shaving head or assembly 11d containing a blade 13d that as seen in FIG. 13 has an angle with respect to the vertical plane of the shaving head 11d defined by the arrow indicated by numeral 126d. This angle may range from 15° to 90°. The supply means 14d is connected to the instrument means 12d and includes a converter contained therein. The supply means 14d is adapted to be plugged directly within an electrical wall outlet as by prongs 124d. The cable 28d connects the instrument means 12d to the power supply means 14d. In this embodiment the converter is preferably of a fixed power setting such that the user merely has to plug the power supply means 14d into an electrical outlet.

As seen in FIG. 13 the shaving head 11d may be made up of two sections joined together with the blade 13d contained therein in a manner described with respect to FIGS. 8-11. As seen a portion of the head section 74d has a cap portion 125d secured thereto such that a channel does not have to be formed on the head section. In this embodiment both the cap 125d and head portion may be of a plastic material and the head portion formed with pins 128d extending therefrom and through openings 129d in the blade 13d such that the pins 128d extend through the cap 125d and headed over therein to form a secure coupling between the related parts so that the mechanical vibratory energy is transmitted therethrough.

Let us briefly consider the blade-guard geometry which is the relationship of the cutting edge of the blade to the upper and lower guards. If the lower guard has a curved profile, then the angle that the upper guard makes with its own axis determines a line which coincides with the upper guard profile and is tangent to the profile of the lower guard. For example, see FIG. 14.

A suitable geometry would be to create a profile Q'RNQP' which can be realized very simply by any precision means. Thus, our blade geometry set-up would be as shown in FIG. 15. If the blade length O'P = L_b is selected, then certain relations are inherent to

this geometry. If we measure the segment of the upper guard from the back edge of the blade we have

$$L_{ug} = \text{upper guard segment} = OO' = L_b - \overline{Q'P}$$

$$\overline{Q'P} = (OQ' / \tan \theta) = (\epsilon + \delta/2) / (\tan \theta)$$

$$L_{lg} = \text{lower guard segment} = O'Q = L_b + d + \overline{MP'}$$

$$\overline{MP'} = (\delta/2 \tan \theta)$$

$$L_{uo} = L_b - (2\epsilon + \delta) / (2 \tan \theta)$$

$$L_{lo} = L_b + d + \delta / (2 \tan \theta)$$

These relations are based on the blade edge P being colinear with O and Q so that OPQ forms a straight line as does P'PO. Now in shaving, the surface OPP'Q is pressed flat against the skin, and the tendency to shave off skin peaks is determined by the gap, PP'. Thus, it is readily seen that the blade guard geometry may be varied so as to open the gap PP' by removing any or all of the shaded area Q'RNQP' shown in FIG. 14.

Furthermore, the extent to which the blade edge, P, protrudes beyond the line OPP'Q (or OQ) may be varied by increasing the blade free length, *l*, by a determinate amount. The thickness *t* and *b* should be selected as thin as possible and still allow precision geometry. For a titanium blade-guard, for instance, the thickness might be one-sixteenth inch for each guard section. This gives a total guard plus blade thickness of $\delta + \frac{1}{8}$ inch. The reason for the profile at O is to permit the blade to vibrate without causing too much heat at the guardblade contact area. This is also the case for the MP'Q surface. Let us consider the range of fan geometry. FIGS. 16 and 17 show variations of fan geometry. It is clear that practically all angles can be produced.

The term fan geometry has been used as well as blade geometry. This term, fan geometry, is a dynamic concept of the inventors considered to be useful in visualizing the appearance in time of the blade edge's movement. When shaving, the blade edge is drawn along the surface of the skin at some shaving speed, which we will call *V_s*. At the same time the blade edge will have a vibration stroke *s* (as shown in FIGS. 15 and 16), having a significant flutter component, and this stroke will vary periodically from a negative maximum value to a positive maximum value and will pass through a zero value when the blade is at either end of its vibratory stroke. For example, if, referring to FIG. 16, we imagine a shaving speed *V_s* of 4 inches per second, and a stroke *s* of 0.001 inch at 30 kilocycles per second, then we can visualize the geometry of the blade edge relative to the shaving surface in relation to time. In one thousandth of a second the blade moves a distance 0.004 inch over the skin, and while doing this the blade performs thirty complete to and fro oscillations. Thus the velocity vector of the blade edge which combines at each instant the shaving velocity, *V_s* with the blade vibration velocity, *V*, will describe a fan like motion such as is shown in FIG. 16A. For each blade vibration stroke and blade frequency as well as with different shaving speeds it is evident that in each case a different fan shaped velocity vibration will be obtained. For the case taken the maximum vibration speed is given by the formula.

$$\text{Max. vibration speed} = \pi f s \quad f = \text{frequency of blade vibration}$$

$$\approx 94 \text{ in/sec. } s = \text{stroke}$$

So, it is evident that the shaving speed is generally very small compared with the peak or maximum vibration speed. This means one can design the shaving head angles by using chiefly the peak vibration velocity of the blade's vibration rather than the vibration speed.

For example, a preferred fan geometry in shaving would be as shown in FIG. 15A, wherein the vibration direction of the blade edge and the blade guard geometry of FIG. 15 are designed so that the said vibration direction is substantially parallel to the skin surface. This provides smooth efficient hair cutting action, while enjoying the benefits of the blade's flutter component of motion as disclosed heretofore.

Now that we have provided an insight into blade-guard and fan geometry, we should have a guide in getting approximate values of resonance frequencies of a clamped-free bar, (the vibrating blade). From Rayleigh's Theory of Sound (Vol. I P. 274) we get a simple formula for the fundamental frequency of vibration of a bar of rectangular cross-section to be:

(Steel) (clamped-free) fundamental frequency = $84,590 t/l^2$ where l is the length of the bar and t is the thickness, t and l are to be taken in centimeters.

This equation is for steel, for which the speed of longitudinal waves was taken as $C=5237 \times 10^2$ cm/sec. For another material we get the frequency from (clamped-free) fundamental frequency = $C \times (84,590/5,237) \times 10^2 t/l^2$ where C is speed of longitudinal waves in the new medium, or if we use 10^3 ips as our C-unit we have $f_o =$ (clamped/free) fundamental freq. = $C_1/(C \text{ steel}) \times 84,590 t/l^2$, t and l in centimeters.

The next higher resonant frequency is $2.648 f_o = f_1$

The second overtone is $4.133 f_o = f_2$

The third overtone is $5.104 f_o = f_3$

The fourth overtone is $5.829 f_o = f_4$

Rayleigh also gives the relative distances of the nodes of vibration from the free end for a clamped-free bar. for f_1 the x/l value from the free end is .2261

for f_2 the x/l value from the free end is (.1321 (.4999

for f_3 the x/l value from the free end is (.0944 (.3588

(.6439

Thus, there is sufficient analytical data from Rayleigh to get information about the lateral vibration of the razor.

The above calculations neglect the rotary inertia of the blade during vibration. This is true as long as K^2/l^2 is small compared with unity, where K is the radius of gyration of the cross-section about an axis through the center of rotation of the cross-section and parallel to the plane of vibration. For a rectangular rod $K^2 = 1/12 t^2$ and so:

$$K^2/l^2 = (1/12) (t^2/l^2)$$

The correction to frequency is (corrected freq.) $1 - 2.32 (K^2/l^2)$ for the fundamental f_o

Thus, if we wish to vibrate the blade at a certain frequency, we may do so by using the calculated data to determine blade-guard relationships and fan geometry.

However, it is evident for blades of thickness t in the range of 0.001 inch to 0.005 inch and of free length l , say, 0.050 inch, that (t/l) is in the order of 1 percent in the largest case and so (K^2/L^2) is of the order of 0.1 percent, which is sufficiently small to justify neglect of the rotary inertia of the blade during vibration. Accordingly, the free length of the blade may be in the range of 0.005 inch to 0.50 inch but preferably in the range of 0.040 inch to 0.20 inch.

Reference to FIGS. 14, 15, 16, 17 suffice to show the general geometrical disposition of the blade element to the vibratory guard system in which it is located rigidly. For purposes of understanding the nature of the dy-

amic vibratory response of the blade element (or elements) when the shaver head is vibrated, it is really only necessary to know the material of the blade, its thickness, and the extent to which it protrudes from the head holding it. If we call the thickness, t , and the protrusion or free length, l , and if we take the blade material to be steel, then it is possible to write down an approximate formula for the resonance frequency of the fundamental flexural vibration of the blade. In cycles per second, this formula is

$$f = 85000 (t/l^2)$$

(1)

where t and l are to be taken in centimeters. In order to get some idea of how the dimensions of an actual steel blade in use would relate to such resonance frequency, let us take the case of a blade with a thickness of 0.003 in. which is approximately 0.008 (or $t = 0.008$ cm). Substituting in the frequency equation we obtain

$$f = (680/l^2)$$

(2)

Now the protrusion, l , may be made equal to many values in a practical shaving head ranging from about 0.1 to 0.5 cm. For example, at $l = 0.1$ cm. we get $f = 680/10^{-2} = 68,000$ Hertz, and if $l = 0.5$ cm., then $f = 680/25 \times 10^{-2} = 2,300$ Hertz.

So that depending on the blade protrusion selected for a 0.003 inch thick blade, one can readily design for a resonance flexural vibration in the range from 2 to 68 KHz. This is compatible with the razor design frequency, which is preferably in the low ultrasonic frequency range. Also it will be appreciated that this range of frequency design can be easily extended by a considerable range by using steel blade material slightly thicker or thinner than the 0.003 inch given in the cited example.

This example is cited so that it may be appreciated that acceptable good shaving technology, which requires blade geometry in the ranges just considered, fits in beautifully with the ultrasonic vibration technology of a thin blade. Thus it is established that we may expect the blade to vibrate somewhat as shown in the figures having a vibration flutter at its edge.

But it must also be remarked that the blade head which holds the blade rigidly is itself undergoing an ultrasonic vibration by virtue of its being a part of the transmission line of an ultrasonic motor. As shown in FIGS. 16 and 17, the blade may be clamped so that it is either parallel to the longitudinal motor axis B-B (FIG. 17) or perpendicular to said axis B-B (FIG. 16) or any other desired angle between 0° and 90° . The effect of selecting a given design angle, θ , in accordance with this disclosure, is that the blade edge, in addition to having the responsive flutter component of vibration as revealed above, said edge may also be endowed with a component of motion along the axis A-A.

In practical use, it has been found that angles, θ , between 30° and 60° yield razors with all the benefits described in this invention. If one inquires why don't we get higher harmonics of the flutter vibration when vibrating the razor head, the answer is simply in the fact that the first harmonic of the bending mode of vibration considered is more than two and a half times the fundamental frequency. So that if, for example the motor is designed to operate at 30 KHz, then, if the blade fundamental flutter frequency is near 30 KHz the

next harmonic will be more than 75 KHz and will therefore be wholly absent as a significant part of the blade's motion. Thus it is seen that although the inventors have devised a simple shaving head satisfying simultaneously sound shaving practice and sound ultrasonic motor transmission line construction, that this very simplicity gives all the elements of combinational versatility to the razor so as to make it a unique new type of shaver embodying a host of beneficial ultrasonically induced effects together with the beneficial results of ordinary shaving practice.

A preferred form of blade assembly which will accomplish the objectives of the present invention as illustrated in FIGS. 4 through 8 may be one having a body portion 66 made of aluminum having total length 0.850 inch, total thickness 0.250 inch and total width 1.55 inch. In a body so dimensioned a blade 0.003 inch may be accommodated within a bonding agent of epoxy material having a thickness of 0.003. The depth of the blade extends through the head about 0.050 inch and is coupled to the body by a bonding agent such as Epibond 123. The protrusion or free length of the blade is approximately 0.050 inch. With reference to FIG. 5, this assembly, when coupled to motor 25 at the end 38, may vibrate at 50 KHz. With reference to FIGS. 16 and 17 the design angle of the blade head assembly may be 45° for this configuration.

FIGS. 18 and 19 illustrate another embodiment of the invention in which the shaving head 11*h* includes an upper or first cutting blade 13*h* and a lower or second cutting blade 130*h* on the body portion section 66*h* with securing means 70*h* to connect the shaving head 11*h*. The blades may be joined to the body portion 66*h* as by coupling means as seen in FIG. 8. The body portion 66*h* is comprised of a base portion 68*h* with a tapered neck section 72*h* terminating in an elongated head section 74*h*. The junction between each section may be by a radius or taper and the blades 13*h* and 130*h* provided with beveled edges 77*h* as seen in FIG. 19. As illustrated a thread portion 78*h* is provided in the rear end 69*h* of the base portion 68*h* along the vertical axis thereof forming said securing means.

The base section 69*h* has an outer peripheral surface 71*h* with the neck section 72*h* having a contoured rear surface 80*h* with a substantially vertical front wall 81*h* and spaced apart side walls 82*h* that each blend with the head section 74*h* at one end thereof and with the body portion 66*h* at their opposite end.

The head section 74*h* is comprised on its front end or face of a lower guard or guide 84*h* extending the width of the shaving head 74*h* with a contoured outer rim 86*h* merging with a horizontal channel or opening 85*h* merging therewith and a top front section 88*h*. The angular relationship between the blades 13*h* and 130*h*, and mounted within the top front section 88*h*, and the guard edge 86*h* is explained with reference to FIGS. 14 and 15. The groove or chamber 85*h*, adapted for containing fluid, has a bottom wall 90*h* that merges with the outer rim 86*h*, a rear wall 92*h* that may be vertical or rearwardly inclined and a top or upper wall 94*h* connected together and the latter terminating at the face or upper guard edge 87*h* of the top front section 88*h* at its brim 95*h*. The head section 74*h* has a curved or tapered rear wall 96*h* that extends from the neck wall 80*h* to the top wall or surface 98*h* and spaced apart from the wall 92*h* in the groove 85*h*.

Horizontal channels 100*h* may be provided in spaced relation to each other through the wall portion to leave remaining ribs 102*h* in a substantially horizontal plane as seen in FIG. 18, with the vibrational energy coupled through the ribs 102*h*. The blades 13*h* and 130*h* are angularly disposed with respect to the vertical axis of the motor and mounted within the head section 74*h*, in a manner to obtain the necessary flexural component of vibration therein. The wall 92*h* within the chamber 85*h* may be in parallel spaced relation to the rear head wall 96*h* or at some other angular relationship as selected.

Accordingly, the electric shaver shown in FIGS. 1-7 is composed of a transducer element, preferably piezoelectric, which is bonded to a transmission member, which is threaded so as to permit the removable attachment of the blade holder transmission element 11*h*. The blade holder element 11*h* is so shaped as the respective blades may be designed to operate in combination with each other and this is achieved for example by altering the thickness of each blade such that the respective components of motion at the free ends 50*h* of blade 13*h* and 131*h* of blade 130*h* are of a different magnitude. As illustrated blade 130*h* has a greater thickness than blade 13*h*. In addition the tailoring of the vibratory motion may be obtained by selecting the free length of the blade from its secured position. In this manner another factor controlling the flexural component of vibration may be obtained.

FIGS. 20, 21 and 22 illustrate another embodiment of the invention in which the shaving head 11*j* includes an upper cutting blade 13*j* and a lower cutting blade 130*j* with a third middle blade 135*j* on the body portion section 66*j* with securing means 70*j* to connect the shaving head 11*j*. The blades may be joined to the body portion 66*j* as by coupling means as seen in FIG. 8. The body portion 66*j* is comprised of a base portion 68*j* with a tapered neck section 72*j* terminating in an elongated head section 74*j*. The junction between each section may be by a radius or taper and the blades 130*j* and 135*j* provided with beveled edges 77*j* as seen in FIG. 20. As illustrated a thread portion 78*j* is provided in the rear end 69*j* of the base portion 68*j* along the vertical axis thereof forming said securing means.

The base section 69*j* has an outer peripheral surface 71*j* with the neck section 72*j* having a contoured rear surface 80*j* with a substantially vertical front wall 81*j* and spaced apart side walls 82*j* that each blend with the head section 74*j* at one end thereof and the body portion 66*j* at their opposite end.

The head section 74*j* is comprised on its front end or face of a lower guard or guide 84*j* extending the width of the shaving head 74*j* with a contoured outer rim 86*j* merging with a horizontal channel or opening 85*j* merging therewith and a top front section 88*j*. The angular relationship between the blades 13*j* and 130*j*, and mounted within the top front section 88*j*, and the guard edge 86*j* is explained with reference to FIGS. 14 and 15. The groove or chamber 85*j*, adapted for containing fluid, has a bottom wall 90*j* that merges with the outer rim 86*j*, a rear wall 92*j* that may be vertical or rearwardly inclined and a top or upper wall 94*j* connected together and the latter terminating at the face or upper guard edge 87*j* of the top front section 88*j* at its brim 95*j*. The head section 74*j* has a curved or tapered rear wall 96*j* that extends from the neck wall 80*j* to the top wall or surface 98*j* and spaced apart from the wall 92*j* in the groove 85*j*.

Horizontal channels 100j may be provided in spaced relation to each other through the wall portion to leave remaining ribs 102j in a substantially horizontal plane as seen in FIG. 18, with the vibrational energy coupled through the ribs 102j. The blades 13j and 130j are angularly disposed with respect to the vertical axis of the motor and mounted within the head section 74j, in a manner to obtain the necessary flexural component of vibration therein. The wall 92j within the chamber 85j may be in parallel spaced relation to the rear head wall 96j or at some other angular relationship as selected.

Accordingly, the electric shaver shown in FIGS. 1-7 is composed of a transducer element, preferably piezoelectric, which is bonded to a transmission member, which is threaded so as to permit the removable attachment of the blade holder transmission element 11j. The blade holder element 11j is so shaped as the respective blades may be designed to operate in combination with each other and this is achieved for example by altering the thickness of each blade such that the respective components of motion at the free ends 50j of blade 13j, 131j of blade 130j and 136j of blade 135j are of a different magnitude. In addition the tailoring of the vibratory motion may be obtained by selecting the free length of the blade from its secured position. In this manner another factor controlling the flexural component of vibration may be obtained.

An additional feature of this embodiment is that gripping means 138j is provided to facilitate the user manually coupling the shaving assembly 11j to the motor. As seen a radial flange 140j is provided on the base portion 68j to coincide with the bottom end 69j. It is appreciated that the exact location is optional, provided it does not interfere with the use of the razor, accordingly the gripping means may be on the base, neck, or head portions. Finger depressions 142j are provided to be engaged by the fingers of the user.

Another feature of the present embodiment, not necessarily related to a multiple blade head or the use of gripping means, is a means of acoustically insulating the body portion 66j by means of a coating 145j that may be of an insulating material having a thickness in the range of 0.010 to 0.060 of an inch. The material may be of a foam or sponge rubber or other poor transmitter of vibratory energy.

To permit the individual user to recognize different types of assemblies each may have a color code and this is accomplished best by providing a layer of material 145j that presents a smooth textured surface.

Although illustrative embodiments of the invention have been described in detail herein reference to the accompanying drawings, it is to be noted that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention, except as defined in the appended claims.

We claim that:

1. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. a blade,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion adapted for receiving an end of said blade,

C. means coupling the vibration induced in said body portion to said blade end in said body portion for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge, and wherein said blade is angularly disposed with respect to the direction of vibration in said base portion so that flexural vibrations are induced in said blade edge, and

D. means for securing said body portion to the driving member to transmit the ultrasonic vibrations thereto.

2. A readily replaceable shaving head as in claim 1, wherein said coupling means includes a fusion at the surfaces of said blade and body portion.

3. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. a blade,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of said blade, and

C. means coupling the vibration induced in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge, wherein said coupling means is comprised of a bonding agent contained within said opening.

4. A readily replaceable shaving head as in claim 3, wherein the bonding agent terminates substantially flush with the surface of said body portion from which the blade extends.

5. A readily replaceable shaving head as in claim 3, wherein said bonding agent in surrounding relation to the blade forms a recessed area, said area being below the surface of said base portion.

6. A readily replaceable shaving head as in claim 3, wherein the bonding agent between said blade and opening is formed having a contoured surface, said contoured surface being concave in form.

7. A readily replaceable shaving head as in claim 1, wherein said body is of a metallic material.

8. A readily replaceable shaving head as in claim 1, wherein said body is of a plastic material.

9. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. a blade,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of said blade, and

C. means coupling the vibration induced in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion for imparting ultrasonic vibratory motion to the blade edge, and wherein said blade is angularly disposed with respect to the direction of vibration in said base portion so that flexural vibrations are induced in said blade edge.

10. A readily replaceable shaving head as in claim 9, wherein said angle between the surface of the blade

and said direction of said vibration is up to 90 degrees.

11. A readily replaceable shaving head as in claim 10, wherein said angle is approximately 30 degrees.

12. A readily replaceable shaving head as in claim 10, wherein said angle is approximately 45 degrees.

13. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. blades,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of each of said blades, wherein said body portion has two blades mounted therein, and

C. means coupling the vibration induced in said body portion to said blade ends in said opening for transmission of ultrasonic vibrations from the supported end of the blades in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edges.

14. A readily replaceable shaving head as in claim 13, wherein the free ends of the blades are of various lengths.

15. A readily replaceable shaving head as in claim 13, wherein said blades are each of a different thickness.

16. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. blades,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of each of said blades, wherein said body portion has three blades mounted therein, and

C. means coupling the vibration induced in said body portion to said blade ends in said opening for transmission of ultrasonic vibrations from the supported end of the blades in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edges.

17. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. a blade,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of said blade, and

C. means coupling the vibration induced in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge, and at the frequency of vibration the blade is of a length and thickness calculated to vibrate flexurally for transmission of vibratory energy at its free edge.

18. A readily replaceable shaving head as in claim 1, wherein the free edge of the blade is flexurally vibrated when said shaving head has vibrations imparted thereto in the frequency range of 5,000 c.p.s. to 1,000,000 c.p.s.

19. A readily replaceable shaving head as in claim 1, wherein said exposed length of said blade extending from said body portion is in the range of approximately .005 inch to 0.50 inch.

20. A readily replaceable shaving head as in claim 1, wherein said blade is of a thickness in the range of substantially from 0.001 inch to 0.10 inch.

21. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. a blade,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion adapted for receiving an end of said blade,

C. means coupling the vibration induced in said body portion to said blade end in said body portion for transmission of ultrasonic vibrations from the supported end of the blade in said body portion for imparting ultrasonic vibratory motion to the blade edge, and wherein said blade is angularly disposed with respect to the direction of vibration in said base portion so that flexural vibrations are induced in said blade edge, and

D. means for securing said body portion to the driving member, said securing means including a threadably engageable portion adapted to mate with a complementary threadable engageable portion on the driving member.

22. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. a blade,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of said blade, wherein the free end of the body portion adjacent said blade defines a chamber adapted for containing a fluid therein and subjected to high frequency vibrations, and

C. means coupling the vibration induced in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge.

23. A readily replaceable shaving head as in claim 1, further comprising gripping means contained on said body portion to permit the user to manually couple said shaving head to the driving member.

24. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:

A. a blade,

B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of said blade,

C. means coupling the vibration in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge, and

- D. means for acoustically insulating the body portion of said shaving head wherein the vibratory motion remains isolated therein and is not transmitted.
25. A readily replaceable shaving head as in claim 24, wherein said means for acoustically insulating the body portion includes vibratory absorbent material that substantially covers the body portion with a layer of material that presents a smooth textured surface.
26. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement comprising:
- A. a blade,
 - B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with an opening receiving an end of said blade, and wherein said body portion includes:
 - a. a base portion,
 - b. a neck portion connected with said base portion at one end thereof,
 - c. an elongated head portion extending transversely to the vertical axis of said base portion and connected with the opposite end of said neck portion and having a lower guard and upper guard in spaced relation to each other, and an opening for receiving an end of said blade contained within said head section and the blade edge extending between said guards, and
 - C. means coupling the vibration induced in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge.
27. A readily replaceable shaving head as in claim 26, wherein said head portion along the horizontal plane thereof has channels extending therein providing vertical ribs for the transmission of the vibrational energy therethrough.
28. A readily replaceable shaving head as in claim 26, wherein said head section along the horizontal plane thereof has a chamber formed behind said blade.
29. A readily replaceable shaving head as in claim 26, wherein said neck portion has a substantially vertical front wall extending from the base portion to said head portion and an upwardly and inwardly tapering rear wall extending from said base section to said elongated head portion.
30. A readily replaceable shaving head for use with an ultrasonic driving member that generates ultrasonic vibrations in a shaving implement, comprising:
- A. a blade having a cutting edge at one end thereof and a thickness in the range of 0.001 inch to 0.10 inch,
 - B. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion including:
 - a. a base portion,
 - b. a neck portion connected with said base portion at one end thereof,
 - c. an elongated head portion extending transversely to the vertical axis of said base portion and connected with the opposite end of said neck portion and having a lower guard and upper guard in spaced relation to each other, and an

- opening for receiving an end of said blade contained within said head section and the blade edge extending between said guards,
- C. means coupling the vibration induced in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge, said blade is angularly disposed with respect to the direction of vibration in said base portion so that flexural vibrations are induced in said blade edge, and
 - D. means securing said body portion to the driving member, said securing means including a threadably engageable portion adapted to mate with a complementary threadably engageable portion on the driving member.
31. A readily replaceable shaving head as in claim 30, wherein said coupling means includes a fusion at the surfaces of said blade and body portion.
32. A readily replaceable shaving head as in claim 30, wherein said coupling means is comprised of a bonding agent contained within said opening.
33. A readily replaceable shaving head as in claim 30, wherein said body is of a metallic material.
34. A readily replaceable shaving head as in claim 30, wherein said body is of a plastic material.
35. A readily replaceable shaving head as in claim 30, wherein said exposed length of said blade extending from said body portion is in the range of approximately 0.005 inch to 0.50 inch.
36. A readily replaceable shaving head as in claim 30, further comprising gripping means contained on said body portion to permit the user to manually couple said shaving head to the driving member.
37. A readily replaceable shaving head as in claim 30, further including means for acoustically insulating the body portion of said shaving head wherein the vibratory motion remains isolated therein and is not transmitted.
38. A readily replaceable shaving head as in claim 30, wherein said blade is of a thickness in the range of substantially from 0.001 inch to 0.10 inch.
39. A readily replaceable shaving head as in claim 38, wherein at the frequency of vibration the blade is of a length and thickness calculated to vibrate flexurally for transmission of vibratory energy at its free end.
40. A readily replaceable shaving head as in claim 39, wherein the free edge of the blade is flexurally vibrated when said shaving head has vibrations imparted thereto in the frequency range of 5,000 c.p.s. to 1,000,000 c.p.s.
41. A readily replaceable shaving head as in claim 40, wherein said vibrations are in the range of 16,000 c.p.s. to 100,000 c.p.s.
42. A readily replaceable shaving head as in claim 30, wherein said head section along the horizontal plane thereof has a chamber formed behind said blade.
43. A readily replaceable shaving head as in claim 30, wherein said neck portion has a substantially vertical front wall extending from the base portion to said head portion and an upwardly and inwardly tapering rear wall extending from said base section to said elongated head portion.
44. A readily replaceable shaving head as in claim 30, wherein said vibrations are of a magnitude to pro-

duce peak accelerations at said blade edge of at least 1,000g.

45. A readily replaceable shaving head as in claim 30, wherein said vibrations are in the range of 16,000 c.p.s. to 100,000 c.p.s.

46. An ultrasonic razor, comprising

A. motor means adapted to be held in the hand for generating mechanical vibrations at an ultrasonic rate,

B. a readily replaceable shaving head including:

a. a blade having a cutting edge at one end thereof and a thickness in the range of 0.001 inch to 0.10 inch, and

b. a body portion capable of supporting ultrasonic vibrations and adapted to be set into vibration in a given direction at ultrasonic frequencies by the driving member, said body portion being provided with a head portion having an opening for receiving an end of said blade, a neck portion coupled to said head portion at one end thereof and a base portion coupled to the opposite end of said neck portion, and

C. means coupling the vibration induced in said body portion to said blade end in said opening for transmission of ultrasonic vibrations from the supported end of the blade in said body portion, wherein ultrasonic vibratory motion is imparted to the blade edge, said blade is angularly disposed with respect to the direction of vibration in said base portion so that flexural vibrations are induced in said blade, and

D. means for securing said body portion to the driving member, said securing means including a threadably engageable portion adapted to mate with a complementary threadably engageable portion on the driving member.

47. A readily replaceable shaving head as in claim 46, a converter connected to said motor means for power-

ing same.

48. A readily replaceable shaving head as in claim 46, wherein said coupling means includes a fusion at the surfaces of said blade and body portion.

49. A readily replaceable shaving head as in claim 46, wherein said coupling means is comprised of a bonding agent contained within said opening.

50. A readily replaceable shaving head as in claim 49, wherein said bonding agent has a thickness on each side of the blade in a range of 0.0005 inch to 0.060 inch.

51. A readily replaceable shaving head as in claim 46, wherein said body is of a metallic material.

52. A readily replaceable shaving head as in claim 46, wherein said body is of a plastic material.

53. A readily replaceable shaving head as in claim 46, wherein said exposed length of said blade extending from said body portion is in the range of approximately .040 inch to 0.20 inch.

54. A readily replaceable shaving head as in claim 46, wherein said blade is angularly disposed with respect to the direction of vibration in said base portion so that flexural vibrations are induced in said blade.

55. A readily replaceable shaving head as in claim 46, further comprising gripping means contained on said body portion to permit the user to manually couple said shaving head to the driving member.

56. A readily replaceable shaving head as in claim 46, wherein said vibrations are in the frequency range of 15,000 c.p.s. to 500,000 c.p.s.

57. A readily replaceable shaving head as in claim 56, wherein said vibrations are in the range of 15,000 c.p.s. to 100,000 c.p.s.

58. A readily replaceable shaving head as in claim 46, wherein said vibrations are of a magnitude to produce peak accelerations at said blade edge of at least 1,000g.

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