

Sept. 2, 1969

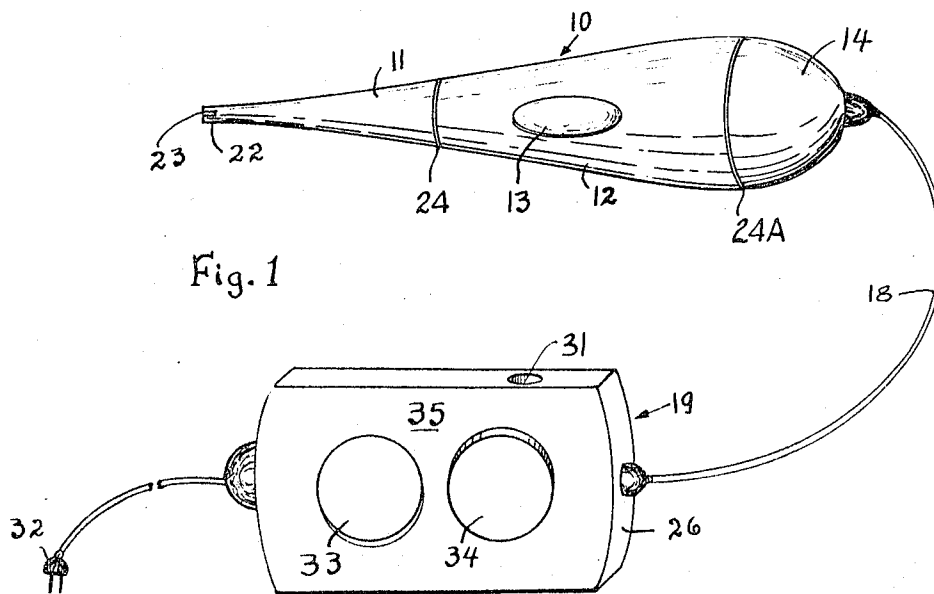
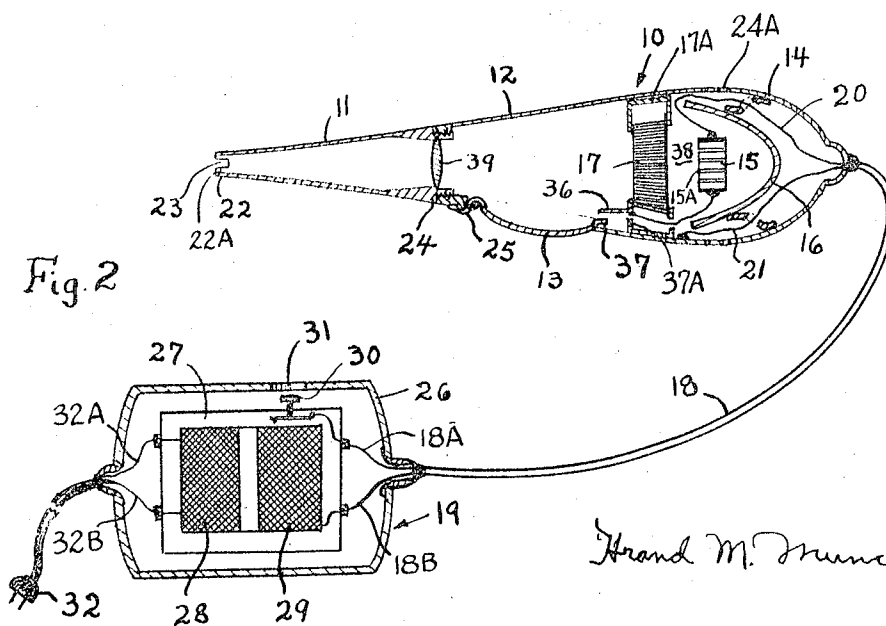
H. M. MUNCHERYAN

3,464,534

LASER ERASER

Filed March 21, 1966

2 Sheets-Sheet 1

*Hand M. Muncheryan*

Sept. 2, 1969

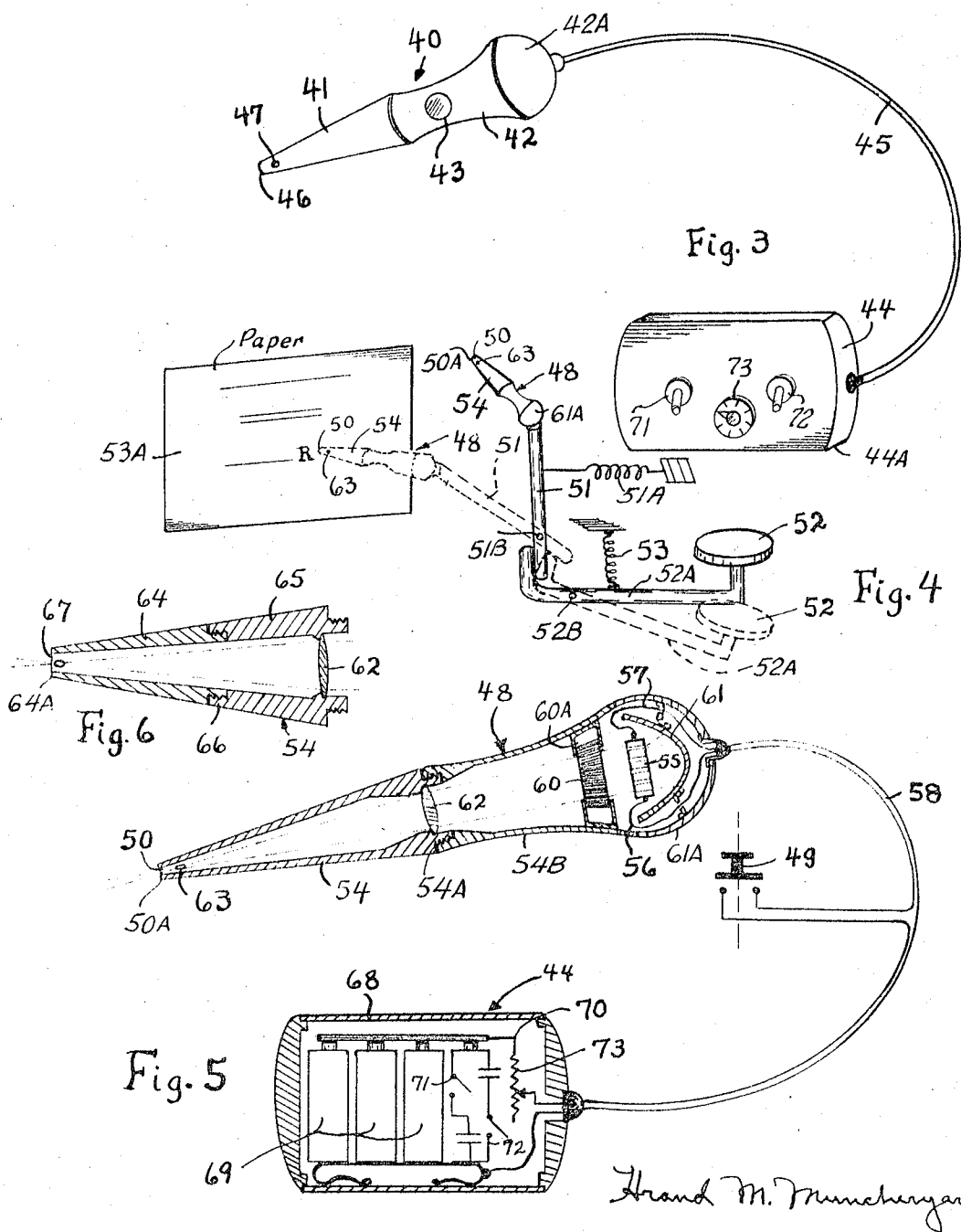
H. M. MUNCHERYAN

3,464,534

LASER ERASER

Filed March 21, 1966

2 Sheets-Sheet 2



1

3,464,534

LASER ERASER

Hrand M. Muncheryan, 7735 Morningside St.,
Orange, Calif. 92667

Filed Mar. 21, 1966, Ser. No. 536,030

Int. Cl. B41j 29/16; H04b 9/00

U.S. Cl. 197—181

25 Claims

ABSTRACT OF THE DISCLOSURE

A laser eraser for general use and application on a typewriter is described. The device comprises a laser generating unit having a fusiform housing that can be accommodated in the palm of one's hand and operated like a conventional eraser, or it can be mounted on a lever of a typewriter key mechanism for operation thereby. A miniature power supply unit with a cable means connected to said laser generating unit through a switch means energizes said laser generating unit. The power supply unit is provided with magnetic means for attachment thereof to a desk top or to the side of a typewriter. Said switch means is made to be incorporated in the wall of said fusiform housing for manual use thereon or to be mounted under said typewriter key for operation thereby upon depression of said key, whereupon said key lever moves said fusiform housing (eraser unit) to the printing point and thereafter said key actuates the switch means, thereby energizing the laser eraser to emit laser radiation which erases the printed error by vaporizing said print.

The present invention relates to laser devices and more particularly to a laser-operated eraser for erasing a typographic error in a printed matter or an error in pencil-drawn or India-ink drawn sketch.

At present, erasers used for removing errors from written words are made of rubber with an abrasive incorporated therein. An erasure is made by rubbing the error character with the rubber eraser until said character is abraded away, whereupon the correct character is written on the space vacated by the error character. Similarly, erasures for correcting drawings or sketches are performed with rubber erasers. In either case, the error is removed by wearing down the written character or drawn line. In doing so, a portion of the paper or the material on which the error appears is worn away and sometimes a hole is produced in the material. The work involved in erasing is also wearisome, frequently annoying, and time- and energy-consuming.

The present invention is designed to eliminate such a burdensome operation as well as to avoid injury to the material containing the erroneous matter. The invention utilizes the radiation beam from a miniature laser generator to vaporize or oxidize the written matter, which is usually colored, such as black or some other dark color that causes a contrast against the white background of the paper or the like. The radiation beam energy is absorbed more readily by the colored character than by the white substrate on which the character is written, since the white color reflects the laser beam in the same manner as it reflects ordinary light. Based on such a principle of radiation energy absorption by black or colored body and reflection by white body, the present invention uses the laser beam to erase a typewritten error or a sketched error from paper or the like.

A principal advantage of the present invention, therefore, resides in the ease, safety to the paper or the like on which the character is written, and instantaneousness with which the erasure of the character can be accomplished, since by directing a small-diameter laser

2

beam upon the written error the latter disappears instantly and completely.

An object of the invention is to provide a small, lightweight laser eraser with a fusiform housing that can be accommodated between the fingers of a person's hand and can be easily manipulated thereby over the exact area of written error to erase it by scanning the laser beam thereupon.

A further object of the invention is to provide a compact and easily portable laser-eraser device energized by a miniature electric power supply having magnetic attachment means to secure said power supply to a flat or varying-configuration steel surface, such as the housing of a typewriter.

A still further object of the invention is to provide a lasing (laser producing) material in the eraser that does not require cooling, and heavy, cumbersome, and non-portable power supply, as would be required by gas-type and certain optically-pumped conventional laser systems. The power supply of the present invention comprises a small battery of dry cells and a bank of capacitors; in a modified embodiment, a reversible transformer of normally step-down operation is used which receives current from an ordinary 115-volt single-phase power source, such as that which supplies an electric typewriter and is available thereon when in use.

Another object of the invention is the adaptability of the laser-eraser unit for incorporation on a typewriter key lever as a standard equipment thereon, whereby depressing the key causes said lever to transport the laser eraser unit to the printing point to erase the error character.

A still further object of the invention is to provide a parabolic reflector inside said fusiform housing with said lasing material or element positioned in the focal point of said reflector to convert the multidirectional laser emission from said lasing element into a unidirectional beam; and, further to provide a coniform fiber optics element in said housing to integrate the laser radiation therein and to direct the radiation along the axis of said fusiform housing.

Another object of the invention is to construct one end of said fusiform housing in a cone-shaped configuration and to dispose an optical lens at the base of said cone in adjacent relation to said laser-integrating element; said cone-shaped section is provided with an axial aperture for the passage of laser beam to the exterior thereof.

A further object of the invention is to construct the cone-shaped lens holding section of the fusiform housing with an axial length from the focal plane of said lens to the tip of said cone-shaped section slightly larger than the focal length of said lens, whereby when the apex or tip of said cone-shaped section is placed on a written error character, the character receives only the divergent cone of laser beam after said beam has come to a focus on the axis within said cone-shaped lens holding section.

Other objects and advantages of the invention will become better understood by reference to the following specification taken in conjunction with the appended drawing, wherein like numerals designate corresponding parts throughout the several views of the invention, and wherein:

FIGURE 1 is a perspective view of the laser-operated eraser unit with an alternating-current supply unit,

FIGURE 2 is a sectional view of the invention shown in FIGURE 1,

FIGURE 3 is a perspective view of a modified embodiment of the laser-operated eraser having a direct-current power supply,

FIGURE 4 illustrates the manner of incorporation of the laser eraser unit on a typewriter, and further illustrates

3

the manner of directing the eraser end to the printing point when the typewriter key is depressed,

FIGURE 5 is a sectional view of a modified laser eraser embodiment whose eraser unit is incorporated on the lever of a typewriter key shown in FIGURE 4 and is operated from a direct-current battery, the laser-triggering switch of said embodiment being located underneath the typewriter key as illustrated between FIGURES 4 and 5, and

FIGURE 6 is an isolated sectional view of an adjustable-beam lens holder.

Referring to the drawing, the laser-operated eraser comprises two main parts, a laser-eraser unit 10 and a power supply unit 19. The laser-eraser unit 10 has a housing formed of a fusiform configuration and may be made of plastic, metal, or other suitable material. The laser-eraser unit 10 housing comprises three interconnected sections: a coniform end section 11 which holds a lens 39, an intermediate section 12 having a pushbutton laser-triggering switch 13 and a light- or laser-integrating wafer 17, and a hemispherical section 14 at the opposite end of the housing containing a parabolic reflector 16 and laser-generating elements 15 disposed in the principal focus of the reflector 16. The light-integrating wafer 17 collects and integrates the laser radiation from the laser-generating elements 15, from reflector 16, and that reflecting from other directions (stray radiation) and projects the integrated radiation on lens 39 in the coniform end section 11. The light-integrating wafer 17 is made of fiber optics and is provided at the periphery thereof with supporting means 17A for attachment of wafer 17 to the wall of said intermediate section 12. An electric cable 18 connects the laser-eraser unit 10 through switch 13 to the power supply unit 19, which receives 115-volt power from a conventional alternating-current power outlet. The voltage is normally stepped down in the power supply unit 19 to a suitable value, such as 5 to 35 volts, prior to its application across the laser-generating elements 15 to activate said elements 15 to emission of laser radiation, whose beam characteristic is independent of diffraction limitations within said parabolic reflector 16. The current to the laser-generating elements 15 is led from the power supply 19 through cable 18, coupling conductor leads 20 and 21, and pushbutton switch 13.

The fusiform housing of the laser-eraser unit 10 measures from 2.5 to 4.0 inches in length and 1.0 to 1.5 inches in the largest diameter thereof. The coniform section 11 tapers down to approximately $\frac{1}{8}$ inch in diameter at the terminal end or apex 22 thereof; the laser exit port 22A is located axially thereof. The terminal end 22 contains a split tip 23 through which vaporized particles of the erased print escape into the atmosphere. The three sections 11, 12, and 14 are secured together by a male-and-female screw-thread attachment means 24 and 24A. This type of attachment permits the various internal parts to be mounted in the corresponding sections prior to the assembly of the three sections 11, 12, and 14 together. The pushbutton switch 13 is maintained normally open by the resilient action of the ribbon spring 25. The external surfaces of the pushbutton switch 13, the intermediate section 12, and the hemispherical section 14 may be coated, if desired, with a thin coating of dielectric material, such as a tough-textured epoxy paint, to electrically insulate the surfaces of sections 12 and 14 from conductor lead 21, when the fusiform housing is made of metal. This latter procedure, however, is not essential since the voltages used across the laser-generating elements 15 are very low and harmless to the operator of the device. The switch 13 may be replaced by a conventional pushbutton switch and, in such an event, no insulation would be necessary on the metal surfaces as mentioned above; conventional pushbutton switches are self-insulating to the housing on which they are employed. In the case where the sections 11, 12, and 14 are made of plastic material, the lead 21 may be connected to a metal contact cap

4

that may be provided at contact point 37, instead of being connected to the hemispherical section 14. With such an arrangement, or by using a conventional pushbutton switch, the fusiform housing may then be made of either plastic or metal, without further insulation considerations.

The portable power supply unit 19 comprises a housing 26 enclosing a reversible transformer 27 having a 115-volt section 28 and a step-down voltage section 29, which is provided with a variable voltage control 30 for adjusting the voltage, thereby varying the laser emission energy necessary for various widths of characters or lines to be erased. For instance, for erasing heavier characters or lines a higher voltage is required than for lighter characters or lines. While in the present laser generator it is the current that produces the emission of laser radiation, it is a known fact that a change of voltage will produce a corresponding change in current, all other factors being equal. The voltage adjustment can be made by means of a screwdriver inserted through the aperture 31 in the housing 26 and by rotating the control 30 adapted to receive the point of the screwdriver. The transformer 27 can be reversed by reversing the positions of sections 28 and 29 in the housing 26; this operation is accomplished by disconnecting the leads 18A and 18B from section 29, and leads 32A and 32B from section 28, reversing the positions of the coil sections 28 and 29 in the housing, and then connecting the respective leads to the sections 28 and 29. A step-down arrangement of the transformer 27 is chosen in the application described herein and shown in FIGURE 2.

Preparatory to the operation of the laser eraser, the plug 32 of power supply unit 19 is inserted into a 115-volt A-C outlet; in using a laser eraser on an electric typewriter, the plug 32 may be connected to the input power of the typewriter. For operation of the laser eraser, the power supply unit 19 may be placed either on the typewriter table or attached to the side of the typewriter by means of a pair of magnets 33 and 34 provided on the front plate 35 of the power supply housing 26. The magnets 33 and 34 are rotatable on their axes; their surfaces are flat and bevelled at an angle from 5 to 10 degrees with respect to their opposite surfaces contiguous with the front plate 35. Thus, the power supply housing 26 can be attached to the typewriter housing by rotating the magnets 33 and 34 until they conform to the surface configuration of the typewriter housing. The laser eraser unit 10 then is grasped in hand in any convenient manner, such as in the manner of holding a pen or a pencil, the exit port end 22 is placed over the character to be erased, and the laser-triggering switch 13 is depressed. This action closes the contact points 36 and 37, the current being fed to the contact point 37 through metal sections 12 and 14, as explained previously. As a result, a current flows across the lasing elements 15, which then emit laser radiation with an intensity directly proportional to the magnitude of the forward current controlled by voltage, there being no minimum threshold current specified. A dielectric stud 37A fastened in the wall of section 12 electrically insulates the contact point 36 from contact point 37.

The radiation from the lasing elements 15 propagates in all directions in chamber 38, and is independent of diffraction limitations characteristic to ruby-type lasing elements. The parabolic reflector 16 transforms the radiation incident thereupon into a parallel beam and directs it to the conically formed fiber-optics wafer 17 placed with its flat surface at right angles to the laser beam projecting from the parabolic reflector 16. The wafer 17 also collects stray radiations incident thereupon from directions as small as 30 degrees with respect to the wafer surface and directs the radiation beam upon an optical lens 39 disposed in the coniform end section 11. The lens 39 then converges the beam to a focus of several mils in diameter within the coniform end section 11 in adjacent relation to the split tip 23. The divergent beam from the focus emerges from the exit port end 22 with a beam-cone diam-

eter of 50 to 200 mils, depending on the distance between the optical plane of the lens 39 and the split tip 23.

The lens 39 is secured adjacent the base of the coniform end section 11, the optical plane of said lens 39 being in contraposition to the fiber-optics wafer 17. The focal length of the lens 39 is so selected that when the laser beam passes through said lens 39, the beam becomes focused within the end section 11 and not at the terminal end 22. Consequently, the character to be erased is not directly in the focus of the laser beam, since the beam focus is the hottest point in the projecting radiation beam and it is not essential to use the hottest point of the beam to erase a character or a line; a circular area in the beam slightly forward to the focus (about 2 to 3 millimeters, depending on beam energy) is usually preferable because of the larger circular size of the beam than the focus size, beam homogeneity, and better controllability of the laser beam energy. For example, a 4-joule laser beam energy expanded for 2 millisecond duration will have a power intensity of 200 kw./cm.² at an area of 1 square millimeter, the area of a small letter.

The lasing elements 15 may be an optically coupled ruby, neodymium-doped glass, or garnet, but I have chosen the use of an array of semiconductor lasing units, such as the diodes of gallium arsenide, indium arsenide, silicon carbide, and similar lasing elements. In an array of any one of semiconductor materials, for instance, gallium arsenide, the diodes are placed adjacently to each other and provided with a fine slit 15A therebetween; the semiconductor lasing elements as arranged and employed in the manner described herein do not require cooling artificially. When a current is passed through the array of diodes placed in series with respect to the current flow (although parallel connection may also be used), the diodes emit a laser radiation through the slits 15A in circular planes perpendicular to the axis of the array as shown. The activating current varies between 1 to 40 amperes at 1 to 15 volts for the semiconductor-type lasing elements; however, the laser beam energy below the range of 15 to 40 amperes at 3 to 15 volts cannot be utilized effectively in the present invention. For ruby and neodymium-doped glass lasing elements, higher pumping voltages are necessary, and hence the purpose of the reversible transformer 27 in the A-C power supply.

A modified embodiment of the invention is shown in FIGURE 3, in which the numeral 40 designates the laser eraser unit (similar to laser eraser unit 10 shown in FIGURE 2) and may be constructed of the same material as unit 10. The laser eraser unit 40 is formed of three sections: a forward coniform section 41 containing an optical lens similarly positioned as lens 39 or lens 62 (shown in FIGURES 2 and 5 respectively), an intermediate section 42 provided with a pushbutton laser-triggering switch 43 of similar operative arrangement as switch 13 of laser-eraser unit 10, and a hemispherical section 42A which contains laser-generating elements and a reflector, both of similar construction and arrangement respectively as lasing elements 55 and reflector 61 shown in FIGURE 5. A D-C power supply unit 44 furnishes laser-generating power to the laser-eraser unit 40 through the cable 45 connected therebetween. The power supply unit 44 is adapted with a flat base section 44A so that the power supply can rest on any flat surface during operation of the eraser unit 40.

To operate the laser-eraser unit 40, the unit is held between the fingers, as in holding a pencil, and scanned over the error character or line by placing the terminal end 46 in abutment with or adjacent the error character to be erased; while scanning, the switch 43 is depressed. This latter action energizes the laser-generating elements in the eraser unit 40, producing a pulse of laser beam which vaporizes the error character. No effect is produced on the material containing the character thereupon, since the colored character possesses a higher coefficient of absorption of laser radiation than the white background paper. In order that the vaporized matter will not plug up the

beam exit port at point 46, the coniform section 41 is provided with an aperture 47 through which the gaseous medium escapes into the atmosphere.

A further modified embodiment of the laser-eraser unit 40 is shown in FIGURE 5 and is designated by numeral 48. In this embodiment, the switch 43 is replaced by a switch 49 which is located outside of the laser-eraser unit 48, this arrangement being the only internal structural arrangement difference between the laser-eraser units 40 and 48. The cable 45 is also replaced by cable 58 for expedience of locating the switch 49, as will be presently discussed. The laser-triggering switch 49 is a pushbutton-type switch and is normally open, and may be closed manually by pressing thereupon. The switch 49 may be permanently located on a typewriter and secured underneath a typing key, such as an exemplary key 52 shown in FIGURE 4. In the latter case, the laser-eraser unit 48 is also permanently attached, as a standard equipment, to the lever of the same key, such as key lever 51 shown in FIGURE 4.

FIGURE 4 in association with FIGURE 5 illustrates a simplified arrangement for incorporating and applying the laser-operated eraser on a typewriter. The typewriter key 52 actuates, through lever 52A fulcrumed on pin 52B, the lever 51 fulcrumed on pin 51B. The laser-eraser unit 48 is mounted by its hemispherical section 61A on the terminal end of lever 51. The springs 53 and 51A maintain the key 52 and the eraser unit 48 in a normal position shown by the solid-line sketch. The laser-triggering switch 49 is disposed underneath the key button 52, a short distance therefrom. An exemplary typing paper 53A, simulating as if mounted on a typewriter carriage, contains an exemplary error character R to be erased. When the key 52 is depressed, the terminal point 50A (FIGURE 5) at exit port 50 of the laser-eraser unit 48 moves to the printing area where the character R is located, illustrated by the broken-line sketch in FIGURE 4. Thereafter, the key 52 continues to move slightly further down and actuates the switch 49; this action produces a burst of laser radiation which passes through the exit port 50 and erases (vaporizes) the character R. Upon releasing the key 52, the eraser unit 48 moves back, by springs 51A and 53, to the original position designated by the solid-line sketch. If there is more than one character to be erased, the key 52 is depressed for each one of the characters moved into position by the typewriter carriage. Since laser radiation cannot be produced until the eraser unit 48 has contacted the printing point, this action protects the typist from receiving laser radiation accidentally.

The internal elements of the laser-eraser unit 48 are in general similar to those shown in the laser-eraser unit 10 construction, FIGURE 2. The laser-emitting elements or crystals 55 are disposed in the focal point of reflector 61 of hemispherical section 61A and receive a laser excitation voltage from the carrier means or leads 56 and 57 connected through cable 58 to the D-C power supply 44. A laser-beam-intergrating coherent fiber-optics wafer 60 having a coniform configuration is attached by a supporting means 60A at the periphery thereof to the intermediate section 54B and in adjacent relation to said laser-emitting elements 55, which are injection laser type. The fiber-optics wafer 60 collects the laser radiation from the parabolic reflector 61 and the laser-emitting elements 55 positioned at the focal point of said reflector 61, and directs the resultant radiation beam to a lens 62 mounted in the coniform section 54, which is joined to the intermediate section 54B by a screw-thread connecting means 54A. The aperture 63 in the end section 54 serves as an exit for the vaporized effluents from the error character during erasure.

The coniform end section (lens holder) 54 may be constructed of two pieces, for erasing various-size characters, such as that illustrated in FIGURE 6. In the latter figure, a terminal section 64 is threaded at one end which is fastened to the lens-holding section 65 having mating threads thereon as at section 66. Thus, by rotating the

section 64 with respect to section 65 in the manner of loosening section 64 from section 65, the distance between the lens 62 and the terminal point 64A at exit port 67 increases. This operation increases the diameter of the laser beam cone that is incident on the error character to be erased, whereby larger-size characters or wider lines can be erased by means of the laser beam. Conversely, by screwing back the section 64 to section 65, in the manner of tightening section 66, the diameter of the beam cone at laser exit port 67 decreases, whereby smaller-size characters and finer lines are erased. In increasing or decreasing the distance between the lens 62 and the plane of the beam cone at exit port 67, the laser energy must be adjusted correspondingly to compensate for this change. This energy adjustment can be made by means of the control 30 of the A-C power supply unit 19 or by means of the variable resistor 73 of the D-C power supply 44. By the terms "beam cone" as used herein, it is meant the circular base of the conical laser beam having become divergent after being focused to an axial point within the end section, such as section 54 or section 11.

The foregoing beam cone-energy relations can be further explained by stating that for a larger laser beam cone incident on a character to be erased a greater laser energy is required, and for a smaller incident laser beam cone a smaller laser energy is required, since the character to be erased is not at the focus of the laser beam but away from it at some distance where the laser beam is divergent, as illustrated in FIGURES 5 and 6. Thus, the diameter d of the divergent beam cone at the tip 50A, terminal point 64A, or at end point 46, may be given by the relation

$$d = \frac{D \times s}{S}$$

wherein D is the diameter of lens 62 (or 39), s is the distance between the laser focus and tip 50A (point 64A or point 46), S is the distance between the optical plane of the lens (such as 62) and the laser focus. The beam-cone diameter can also be varied by replacing a lens of one focal length with one of another focal length, since S is essentially equal to the focal length of the lens.

For nonelectric typewriters, and where no electric outlet is available, the D-C power supply unit 44 with the eraser unit 40 or 48 may be used. The power supply unit 44 consists of a housing containing a battery of dry cells 69 connected across a bank of capacitors 70, wherein the individual capacitors may have equal or different capacitances. The battery of dry cells 69 charges the capacitor bank 70 to a value determined by the positions of the capacitor switches 71 and 72. The switches 71 and 72 are only illustrative; an array of 10 to 15 capacitors may be employed, each capacitor being charged with 30 or 60 microfarads and the total capacitance being controlled by one commutator-type switch having 10 to 15 contact points for the respective capacitors. By closing all the available switches, such as the switches 71 and 72 in the present illustration, the capacitance of the power supply increases, thus increasing the pulse energy supplied to the lasing elements. By opening one or the other of the switches, decreases the capacitance of the pulse-forming RC network and, hence, the pulse energy to the lasing elements decreases. Thus, increasing or decreasing the capacitances respectively increases or decreases the laser beam energy, maintaining all other factors equal. For continuous operation, both of the capacitors are removed from the circuit.

I claim:

1. A laser eraser comprising: a laser-eraser unit with a housing having a fusiform configuration for accommodation in a person's hand and operated thereby, a power supply unit having control means therefor, a cable means for connecting said power supply unit to said laser-eraser unit, and a switch means in the circuit of said cable means; said fusiform housing being formed of a hemispherical section at one end, an intermediate section, and a con-

form end section tapering down to a tip provided with a radial opening and a laser-exit port disposed centrally to said tip; said sections being joined together by rotatively adjustable connecting means; a parabolic reflector means disposed within said hemispherical section and a laser-generating means disposed at the focal point of said reflector means; light-integrating means disposed in said intermediate section adjacent said laser-generating means to receive laser radiation from said laser-generating means and said parabolic reflector means and to direct said radiation into said coniform end section; an optical lens disposed in said coniform end section to receive said laser radiation directed thereto by said light-integrating means and to focus said radiation within said coniform end section in axial relation thereof to a point adjacent said tip of said end section; said switch means transmits current from said power supply unit to actuate said laser-generating means to emission of laser radiation, and said laser radiation after passing through said laser-exit port, vaporizes a printed character placed in the path thereof adjacent said tip by selective absorption of said laser radiation generated by said laser-generating means.

2. A laser eraser as defined in claim 1, wherein said intermediate section is provided with an aperture in the wall thereof and wherein said switch means is incorporated in said aperture for manual operation of said switch means by depressing thereupon.

3. A laser eraser as defined in claim 1, wherein said laser-generating means disposed at the focal point of said reflector means comprises a plurality of laser-emitting elements electrically connected together in series.

4. A laser eraser as defined in claim 1, wherein said laser-generating means disposed at the focal point of said parabolic reflector means comprises a plurality of injection laser crystals electrically connected together in series.

5. A laser eraser as defined in claim 1, wherein said portable power supply unit comprises a housing, a reversible transformer disposed within said housing, said transformer receives an alternating current from an external source and furnishes a controlled voltage at the output section thereof, and wherein said control means is disposed in the output section of said transformer, and an aperture formed in the wall of said housing in register with said control means for adjustment thereof by means of a screwdriver externally introduced through said aperture.

6. A laser eraser as defined in claim 1, wherein said coniform end section is formed of two parts joined together by a rotatively adjustable connecting means, one of said parts having a base section with a lens disposed therein and the other part forming the terminal portion of said coniform end section and terminating in an apex provided with a radial opening adjacent thereto.

7. A coniform end section as defined in claim 6, wherein the length of said coniform end section formed of two parts is adjusted by rotating one of said parts with respect to the other part at said adjustable connecting means, thereby varying the distance of said lens from said apex of said part forming the terminal end of said coniform end section.

8. A laser eraser as defined in claim 1, wherein said light-integrating means is a wafer of coherent fiber-optics having a coniform configuration and is provided with supporting means in the periphery thereof for attachment of said wafer to the wall of said intermediate section.

9. In combination with a typewriter, a laser eraser comprising: a housing having a fusiform configuration formed of a hemispherical section, an intermediate section, and an end section provided with an axially disposed opening and a radially disposed opening; said sections being joined together by adjustable connecting means; a parabolic reflector means disposed within said hemispherical section, a laser-generating means disposed at the focal point of said reflector means; light-integrating means disposed in said intermediate section adjacent said laser-

generating means, an optical lens disposed in said end section to focus a laser beam directed thereto by said laser-generating means and said parabolic reflector means through said light-integrating means; a portable power supply having control means therefor, magnetic means for attaching said portable power supply to said typewriter, cable means for connecting said power supply to said laser-generating means, and switch means in said cable means; said housing being mounted on one end of a lever pivotally mounted in said typewriter for movement of said housing to and from the printing point, the other end of said lever being operatively connected to a key lever, said switch means being disposed beneath said key lever for operation thereby, whereby depression of said key lever will move said housing to said printing point and thereafter operate said means, thereby actuating said laser eraser to vaporize a printed character by selective absorption thereof of the laser beam generated by said laser-generating means.

10. A laser eraser as defined in claim 9, wherein said portable power supply connected to said laser-generating means through said cable means comprises a housing, a current source disposed in said housing, a bank of capacitors for storing electrical energy disposed in said housing and connected to said current source, and control means in said bank of capacitors to adjust the stored energy thereof and control the intensity of emission of laser radiation from said laser-generating means.

11. A laser eraser as defined in claim 9, wherein said cable means is a double-wire electrical conductor and wherein said switch means is a normally-open pushbutton switch incorporated in the circuit of said cable means to turn on and off the power to said laser operated eraser.

12. A laser-eraser as defined in claim 9, wherein said magnetic means for attaching said portable power supply to a typewriter comprises a plurality of magnets rotatably attached to the housing of said power supply, the surfaces of said magnets being flat and bevelled at an angle between 5 to 10 degrees with respect to their opposite surfaces.

13. In a laser-eraser as defined in claim 9, wherein said switch means is disposed beneath said key lever and operatively connected thereto, said switch means being a pushbutton switch normally at open position and is closed when said key lever is depressed.

14. A laser-eraser as defined in claim 9, wherein said laser-generating means disposed at the focal point of said parabolic reflector means comprises a plurality of series-connected laser-emitting elements, each element being a diode of indium arsenide.

15. A laser-eraser as defined in claim 9, wherein said laser-generating means disposed at the focal point of said parabolic reflector means comprises a plurality of series-connected laser-emitting elements, each element being a diode of silicon carbide.

16. A laser-eraser as defined in claim 9, wherein said laser-generating means disposed at the focal point of said parabolic reflector means comprises one of the class of solid state lasing elements characterized by ruby, neodymium-doped glass, and garnet.

17. A laser-eraser as defined in claim 9, wherein said laser-generating means disposed at the focal point of said reflector means comprises a plurality of series-connected laser-emitting elements, each element is a diode of gallium arsenide.

18. A laser-eraser as defined in claim 9, wherein said laser-generating means disposed at the focal point of said parabolic reflector means comprises a multiplicity of solid state lasing elements having radiation emission characteristics independent of the diffraction limits of said lasing elements radiating at said focal point of said parabolic reflector means and being focused by said optical lens.

19. A laser-eraser comprising: a laser-eraser unit, a switch means, and a portable power supply unit having a cable means connecting said power supply unit to said

laser-eraser unit through said switch means; and laser-eraser unit having a fusiform housing configured for accommodation in the palm of the hand and provided with a hemispherical section, an intermediate section, and a coniform end section with an axial aperture at the tip thereof; a parabolic reflector means with a laser-emitting means disposed at the focal point thereof being positioned in said hemispherical section, and conductor means from said cable means passing through the wall of said hemispherical section and being connected to said laser-emitting means through said switch means to conduct energizing current to said laser-emitting means; a light-integrating means having supporting means at the periphery thereof, said light-integrating means being attached by said supporting means to said intermediate section adjacent said laser-emitting means; an optical lens disposed in said coniform end section to receive a laser beam directed thereto from said light-integrating means and to converge said beam to a focus axially within said coniform end section and adjacently to the tip thereof; said laser beam after having converged to said focus becomes divergent as it advances to said tip, the diameter d of the divergent beam cone at said tip of said coniform end section being determined by the relation

$$d = \frac{D \times s}{S}$$

wherein D is the optical plane diameter of said optical lens, s is the distance between the laser beam focus and the tip of said coniform end section, and S is the distance between the optical plane of the lens and the laser beam focus (equal to the focal length of lens); said portable power supply unit being provided with means to attach said power supply unit to a typewriter housing, said fusiform housing being provided at one end with means for mounting said housing on a key lever of said typewriter for movement of said housing to and from a printing point on said typewriter, and said switch means being provided with means to be operatively connected to said key for operation thereby, whereby depression of said key will move said housing to said printing point and thereafter operate said switch means to energize said laser-emitting means to emission of laser radiation.

20. A laser eraser as defined in claim 19, wherein said optical lens in said coniform end section being replaceable by a lens of different focal length to vary the distance s between said laser beam focus and the tip of said coniform end section, thereby varying the diameter d of said divergent beam cone of said laser beam emergent at said tip.

21. A laser eraser as defined in claim 19, wherein said coniform end section being formed of two pieces joined together by a connecting means, said connecting means being adjustable for varying the axial length of said end section, thereby varying the axial position of said laser beam focus with respect to said tip of said coniform end section.

22. In a laser eraser end section as defined in claim 21, wherein the adjustment of said coniform end section varies the axial length of said coniform end section and thereby varies the diameter d of the cone of said laser beam at said tip of said coniform end section.

23. In an article of manufacture comprising: a laser-eraser unit, a portable power supply unit, a switch means, and a cable means connecting said power supply unit to said laser-eraser unit through said switch means; said laser-eraser unit having a housing with a fusiform configuration formed of a hemispherical section, an intermediate section, and a coniform end section, said sections being joined together by adjustable connecting means; said hemispherical section having a parabolic reflector means disposed therein, a laser-generating means positioned in the focal point of said parabolic reflector means, and a pair of electric conductor means extending from said cable means into said hemispherical section through

the wall thereof, one of said conductor means being connected to said laser-generating means and the other of said conductor means being connected to a point within said hemispherical section and electrically insulated from said laser-generating means; said intermediate section being provided therein with a coniform light-integrating means disposed adjacent said laser-generating means to receive laser radiation therefrom and from said parabolic reflector means for directing said radiation axially through said fusiform housing, an aperture formed in the wall of said intermediate section and switch means incorporated therein; said switch means being electrically connected between said laser-generating means and said other of said pair of conductor means which is electrically insulated from said laser-generating means; said coniform end section having at the base portion thereof an optical lens disposed at right angles to the axis of said coniform end section to focus a laser beam directed thereto by said light-integrating means, said coniform end section having at the apex thereof a split tip with an axially disposed laser exit port; the focus of said laser beam being formed on the axis of said coniform end section and in adjacent relation to said split tip; said switch means, upon depression thereof, establishes an electrical contact with said laser-generating means and energizes said latter means to emission of radiation directed to the exterior of said fusiform housing through said light-integrating means, said optical lens, and said laser exit port disposed axially to said split tip.

24. A laser eraser as defined in claim 23, wherein said portable power supply unit comprises a battery of dry cells, a variable resistor, and a bank of varying-size capacitors connected to said battery of dry cells through said variable resistor to form a pulsing current network for furnishing a pulsed current to said laser-generating means.

25. An article of manufacture comprising: a laser beam generator having a fusiform housing accommodable in the palm of hand, said housing being hemispherical at one end tapering coniformly to the opposite end having an aperture disposed at the tip thereof, a laser-emitting means provided with a reflector means partially surrounding said laser-emitting means being disposed in said hemispherical end, a laser-integrating means disposed in said housing in adjacent relation to said laser-emitting means to integrate the laser radiation from said laser-emitting

means and from said reflector means and to project said radiation within said fusiform housing, a lens means disposed in said housing in adjacent relation to said laser-integrating means to direct a laser beam projected thereto by said laser-integrating means to the exterior of said fusiform housing through said aperture at the tip thereof, a miniature power supply unit having electrical conductor means extending into said hemispherical end of said fusiform housing, switch means connected in said conductor means, and laser-excitation carrier means disposed in the hemispherical end of said fusiform housing being operatively coupled to said laser-emitting means and electrically connected to said conductor means through said switch means to energize said laser-emitting means to emission of laser radiation.

References Cited

UNITED STATES PATENTS

2,791,313	5/1957	Paredes	197—181
2,921,662	1/1960	Kowatsch et al.	197—181
3,256,524	6/1966	Stauffer	331—94.5 X
3,305,666	2/1967	Zaromb	219—383
3,314,073	4/1967	Becker.	

OTHER REFERENCES

- Electronics I, vol. 34, No. 47, Nov. 24, 1961, pp. 54—57.
- Journal Franklin Institute, vol. 273, No. 3, March 1962, pp. 262—263.
- The tool and Manufacturing Engineer, June 1962, pp. 85—91.
- Electronics II, May 3, 1963, pp. 20—21.
- Proceedings of the IEEE, vol. 51, No. 10, October 1963, pp. 1374—1376.
- Electronic Industries, February 1964, pp. 68—72.
- Journal of the SMPTE, vol. 73, No. 3, March 1964, pp. 206—212.
- IBM Technical Disclosure Bulletin, vol. 7, No. 3, August 1964, p. 224.

ERNEST T. WRIGHT, JR., Primary Examiner

U.S. Cl. X.R.

15—3.53, 424; 331—94.5; 350—96; 219—121, 383
250—199