US 20050121424A1

(19) United States

(12) Patent Application Publication

Caldwell et al.

(10) Pub. No.: US 2005/0121424 A1

(43) Pub. Date: Jun. 9, 2005

(54) OPTICAL HORNED LIGHTPIPE OR LIGHTGUIDE

(76) Inventors: **Scott Caldwell**, Fairport, NY (US); **Hugh T. McNair**, Webster, NY (US)

Correspondence Address:
HARNESS, DICKEY & PIERCE, P.L.C.
P.O. BOX 828
BLOOMFIELD HILLS, MI 48303 (US)

(21) Appl. No.: 10/729,048

(22) Filed: Dec. 5, 2003

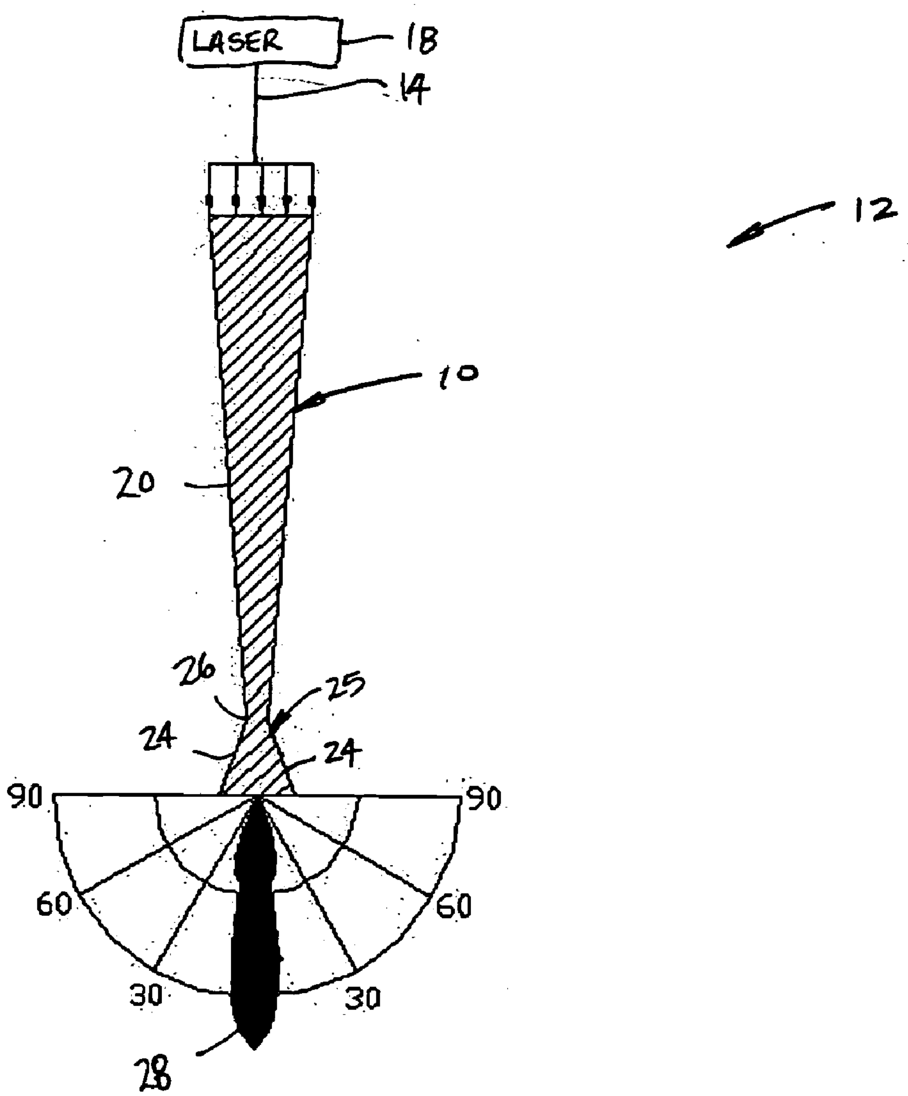
Publication Classification

(51) Int. Cl.[7] B23K 26/20; B23K 26/06

(52) U.S. Cl. 219/121.63; 219/121.73; 219/121.64

(57) ABSTRACT

A laser welding apparatus having a laser source outputting a laser beam and a light transmitting device, chosen from the group consisting essentially of a lightpipe and a lightguide, positioned downstream from the laser source. The light transmitting device transmits the laser beam therethrough. An optical device receives the laser beam exiting the light transmitting device and is operable to converge light lobes exiting the light transmitting device to define a final beam width. The final beam width being narrower than a beam width exiting the light transmitting device.



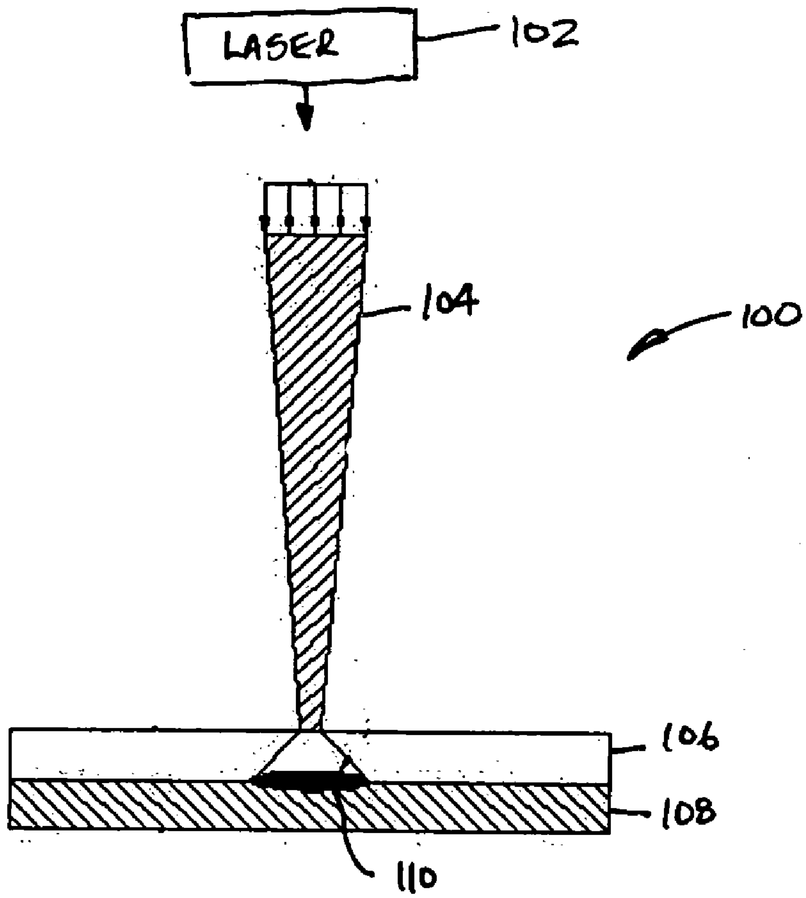


FIG 1
PRIOR ART

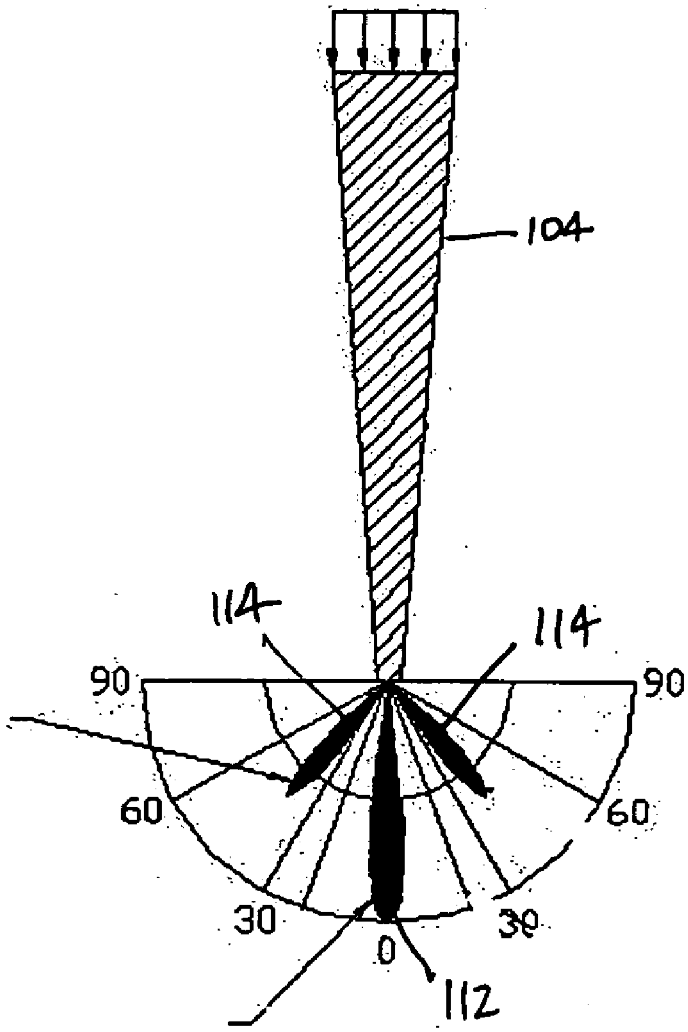


FIG. 2
PRIOR ART

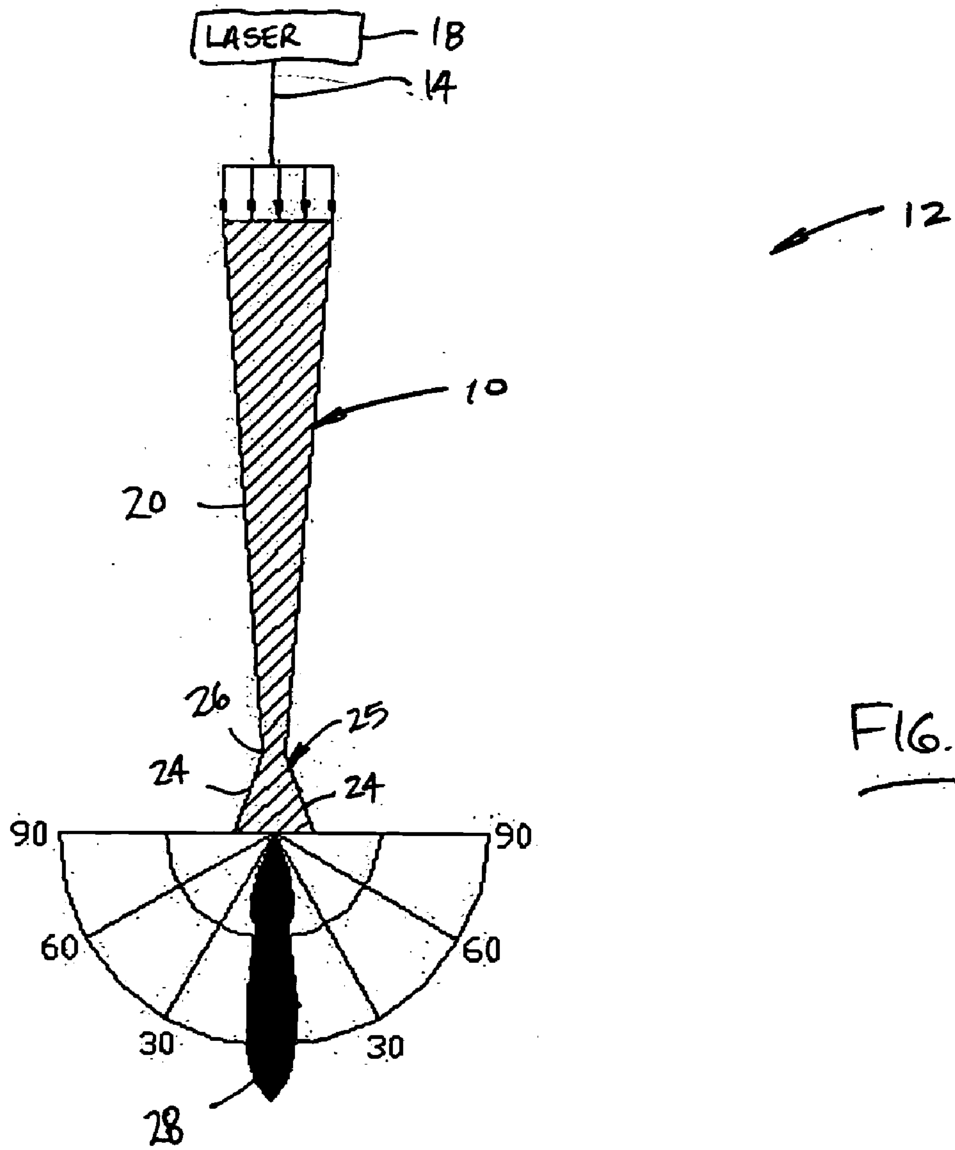


FIG. 3

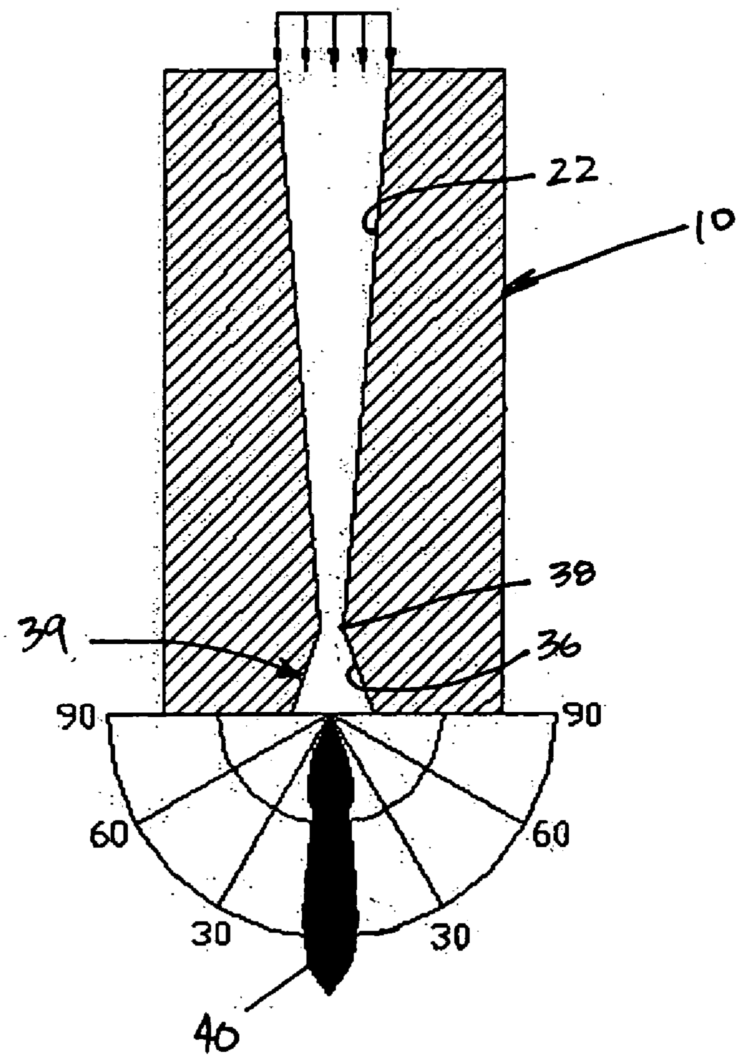


FIG. 4

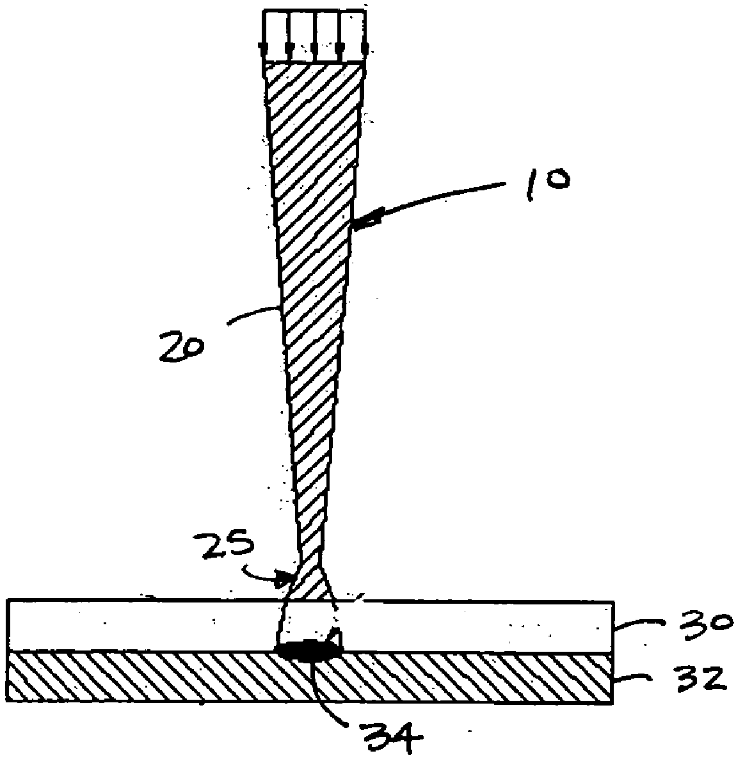


FIG. 5

OPTICAL HORNED LIGHTPIPE OR LIGHTGUIDE

FIELD OF THE INVENTION

[0001] The present invention relates generally to laser welding and, more particularly, relates to lightpipes or lightguides having an optical horn.

BACKGROUND OF THE INVENTION

[0002] Laser welding is commonly used to join plastic or resinous parts, such as thermoplastic parts, at a welding zone. An example of such use of lasers can be found in U.S. Pat. No. 4,636,609, which is expressly incorporated herein by reference.

[0003] As is well known, lasers provide a semi-focused beam of electromagnetic radiation at a specified frequency (i.e., coherent monochromatic radiation). There are a number of types of lasers available; however, infrared lasers or non-coherent sources provide a relatively economical source of radiative energy for use in heating a welding zone. One particular example of infrared welding is known as Through-Transmission Infrared (TTIr) Welding. TTIr welding employs an infrared laser capable of producing infrared radiation that is directed by lenses, diffractive optics, fiber optics, waveguides, lightpipes or lightguides through a first plastic part and into a second plastic part. This first plastic part is often referred to as the transmissive piece, since it generally permits the laser beam from the laser to pass therethrough. However, the second plastic part is often referred to as absorptive piece, since this piece generally absorbs the radiative energy of the laser beam to produce heat in the welding zone. This heat in the welding zone causes the transmissive piece and the absorptive piece to be melted and, with intimate contact, welded together.

[0004] However, in the case of those TTIr welding systems that employ a lightguide or lightpipe, the infrared laser light that exits the lightguide or lightpipe is often outwardly dispersed in a fan or cone shape as it passes through the transmissive piece. This dispersion of light may lead to oversized welding zones. That is, as the light exits the lightpipe or lightguide, the light fans outwardly and impacts a larger area of the absorptive piece and transmissive piece interface. This larger area is consequently heated causing a larger welding zone.

[0005] Accordingly, there exists a need in the relevant art to provide an apparatus for use with a lightpipe or lightguide that is capable of minimizing the size of a weld zone. Furthermore, there exists a need in the relevant art to provide an apparatus for use with a lightpipe or lightguide that is capable of focusing the laser light to a narrower area that could not otherwise be obtained simply with a conventional lightpipe or lightguide. Lastly, there exists a need in the relevant art to provide a lightpipe or lightguide with an optical horn capable of overcoming the disadvantages of the prior art.

SUMMARY OF THE INVENTION

[0006] According to the principles of the present invention, a laser welding apparatus is provided having an advantageous construction and method of using the same. The laser welding apparatus includes a laser source outputting a laser beam and a light transmitting device, chosen from the group consisting essentially of a lightpipe and a lightguide, positioned downstream from the laser source. The light transmitting device transmits the laser beam therethrough. An optical device receives the laser beam exiting the light transmitting device and is operable to converge light lobes exiting the light transmitting device to define a final beam width. The final beam width being narrower than a beam width exiting the light transmitting device.

[0007] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0009] **FIG. 1** is a schematic view illustrating a TTIr welding apparatus employing a lightpipe according to the prior art;

[0010] **FIG. 2** is a schematic view illustrating conventional light distribution exiting the TTIr welding apparatus illustrated in **FIG. 1**;

[0011] **FIG. 3** is a schematic view illustrating a TTIr welding apparatus employing a lightpipe and optical horn according to the principles of the present invention, including the resultant light distribution;

[0012] **FIG. 4** is a schematic view illustrating a TTIr welding apparatus employing a lightguide and optical horn according to the principles of the present invention, including the resultant light distribution; and

[0013] **FIG. 5** is a schematic view illustrating the TTIr welding apparatus employing a lightpipe and optical horn according to the principles of the present invention, including the resultant weld zone.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] The following description of the preferred embodiment is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. Furthermore, it should be understood that although the present invention is described in connection with TTIr welding, the present invention is equally applicable to other forms of welding and/or surface heating using light energy being passed through lightpipes or lightguides. It should also be understood that although the term lightguide will be used here throughout, lightguides are also known as waveguides and, thus, such terms should be understood as being interchangeable.

[0015] By way of background and with reference to **FIGS. 1 and 2**, TTIr welding systems **100** often include a laser **102** outputting a laser light to a conventional lightpipe **104**. This laser light transmitted along conventional lightpipe **104** and through a transmissive piece **106**. The laser light finally impacts an interface between transmissive piece **106** and an absorptive piece **108** at a weld zone **110**.

[0016] As can be seen in **FIGS. 1 and 2**, this laser light often fans outwardly as it exits conventional lightpipe **104** and may further fan outwardly due to the optical effects of transmissive piece **106**. Consequently, weld zone **110** is substantially larger than the exit end of conventional lightpipe **104** due to this effect.

[0017] More particularly, as seen in **FIG. 2**, the angular distribution of laser light exiting conventional lightpipe **104** can be seen. Specifically, as laser light enters conventional lightpipe **104**, it inherently has a certain amount of angular distribution. This angular distribution is exaggerated by the tapered sides of conventional lightpipe **104**. Therefore, as the laser light exits conventional lightpipe **104**, the angular distribution is increased causing a larger than desired weld zone **110**. Still referring to **FIG. 2**, the distribution typically forms a central lobe **112** and a pair of side lobes **114**.

[0018] Referring now to **FIGS. 3-5**, a lightpipe or lightguide assembly **10** is illustrated in accordance with the principles of the present invention. According to the present embodiment, lightpipe or lightguide assembly **10** is adapted for use with a TTIr welding system **12**. As seen in **FIG. 1**, TTIr welding system **12** may include an optional fiber optic bundle **14** comprised of a plurality of optical fibers generally arranged in a circular pattern capable of carrying or transmitting radiative energy in the form of a laser beam therethrough. Fiber optic bundle **14** is operably coupled to a laser source **18**, such as an infrared laser, according to known principles.

[0019] In order to limit the angular distribution of the laser light, lightpipe or lightguide assembly **10** comprises a lightpipe **20 (FIG. 3)** or a lightguide **22 (FIG. 4)**. With particular reference to **FIG. 3**, lightpipe assembly **10** further comprises bounce planes **24** disposed at an exit end **26** of lightpipe **20**. Bounce planes **24** form an optical horn **25** that serves to "bounce" or otherwise reflect the laser light exiting exit end **26** of lightpipe **20** such that side lobes **114** are generally aligned with central lobe **112** to form a combined light lobe **28**. As can be seen in **FIGS. 2 and 3**, combined light lobe **28 (FIG. 3)** of the present invention is considerably narrower than the conventional distribution **(FIG. 2)**. As such, combined light lobe **28** is transmitted through transmissive piece **30 (FIG. 5)** and impacts absorptive piece **32** to define a narrower weld zone **34** compared to conventional weld zone **110**. Lightpipe **20** and bounce planes **24** are preferably made of a dielectric that uses total internal reflection (TIR) and/or mirrored surface to direct light therethrough.

[0020] Similarly, as seen in **FIG. 4**, lightguide assembly **10** further comprises bounce planes **36** disposed at an exit end **38** of lightguide **22**. Bounce planes **36** form an optical horn **39** that serves to "bounce" or otherwise reflect the laser light exiting exit end **38** of lightguide **22** such that side lobes **114** are generally aligned with central lobe **112** to form a combined light lobe **40**. As can be seen in **FIGS. 2 and 3**, combined light lobe **40 (FIG. 3)** of the present invention is considerably narrower than the conventional distribution **(FIG. 2)**. As such, combined light lobe **40** is transmitted through transmissive piece **30 (FIG. 5)** and impacts absorptive piece **32** to define a narrower weld zone **34** compared to conventional weld zone **110**. Preferably, lightguide **22** and bounce planes **36** employ a void having mirrored walls to conduct light therethrough.

[0021] As should be appreciated, the present invention enables a laser welding apparatus, which employs a lightpipe or lightguide, to produce a substantially narrower laser welding beam capable of producing a narrower weld zone compared to conventional laser welding apparatuses. Consequently, laser welding apparatuses using lightpipes or lightguides may now be used for a greater range of delicate welding operations and/or improved weld features. Additionally, the reflecting of the side light lobes into a concentrated combined light lobe provided improved welding efficiency.

[0022] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. A laser welding apparatus comprising:

a laser source outputting a laser beam;

a light transmitting device chosen from the group consisting essentially of a lightpipe and a lightguide, said light transmitting device being positioned downstream from said laser source, said light transmitting device operable to transmit said laser beam therethrough; and

an optical device positioned downstream from said light transmitting device, said optical device operable to converge light lobes exiting said light transmitting device to define a final beam width, said final beam width being narrower than a beam width exiting said light transmitting device.

2. The laser welding apparatus according to claim 1 wherein said light transmitting device is integrally formed with said optical device to form a single unit.

3. The laser welding apparatus according to claim 1 wherein said optical device is an optical horn having outwardly tapered bounce planes.

4. The laser welding apparatus according to claim 3 wherein said outwardly tapered bounce planes define a first angle therebetween and said light lobes exiting said light transmitting device define a second angle, said first angle being less than said second angle.

5. A laser welding apparatus comprising:

a laser source outputting a laser beam;

a light transmitting device chosen from the group consisting essentially of a lightpipe and a lightguide, said light transmitting device being positioned downstream from said laser source, said light transmitting device operable to transmit said laser beam therethrough; and

an optical device integrally formed with said light transmitting device, said optical device being positioned downstream from said light transmitting device, said optical device being operable to converge light lobes exiting said light transmitting device to define a final beam width, said final beam width being narrower than a beam width exiting said light transmitting device.

6. The laser welding apparatus according to claim 5 wherein said optical device is an optical horn having outwardly tapered bounce planes.

7. The laser welding apparatus according to claim 6 wherein said outwardly tapered bounce planes define a first angle therebetween and said light lobes exiting said light transmitting device define a second angle, said first angle being less than said second angle.

8. A method of laser welding a first part to a second part, said method comprising:

outputting a laser beam;

passing said laser beam through a lightpipe to define a central light lobe and a side light lobe;

passing said laser beam exiting said lightpipe through an optical horn such that said side light lobe is generally reflected toward said central light lobe to define a combined light lobe; and

heating at least one of a first part and a second part with said combined light lobe to create a weld therebetween.

9. A method of laser welding a first part to a second part, said method comprising:

outputting a laser beam;

passing said laser beam through a lightguide to define a central light lobe and a side light lobe;

passing said laser beam exiting said lightguide through an optical horn such that said side light lobe is generally reflected toward said central light lobe to define a combined light lobe; and

heating at least one of a first part and a second part with said combined light lobe to create a weld therebetween.

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