

United States Patent

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[54] **APPARATUS AND METHOD FOR PERFORATING SHEET MATERIAL**
29 Claims, 2 Drawing Figs.

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[51] Int. Cl. **H05b 7/18**
[50] Field of Search..... **219/383-385,**
 121 L; 101/1; 331/94.5; 350/3.5;
 346/76.1, 108-109

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ABSTRACT: Apparatus for perforating sheet material by means of a beam emitted from a laser source which comprises:

- A. a means for moving the sheet material;
- B. a laser source;
- C. a reflective hologram, said hologram:
 - 1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon; and
 - 2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and
- D. means for causing the high-intensity spot images to impinge upon certain areas of the sheet material for a duration that is greater than the duration of impingement in other areas, said sheet material areas of greater duration of impingement receiving sufficient energy to cause perforations to be formed therein, and said sheet material areas of lesser duration of impingement receiving impingement in the amount of from no impingement at all to an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

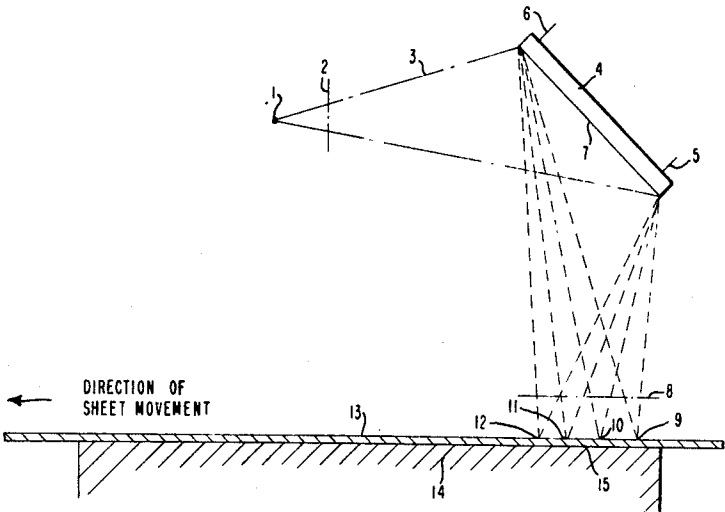


FIG. 1

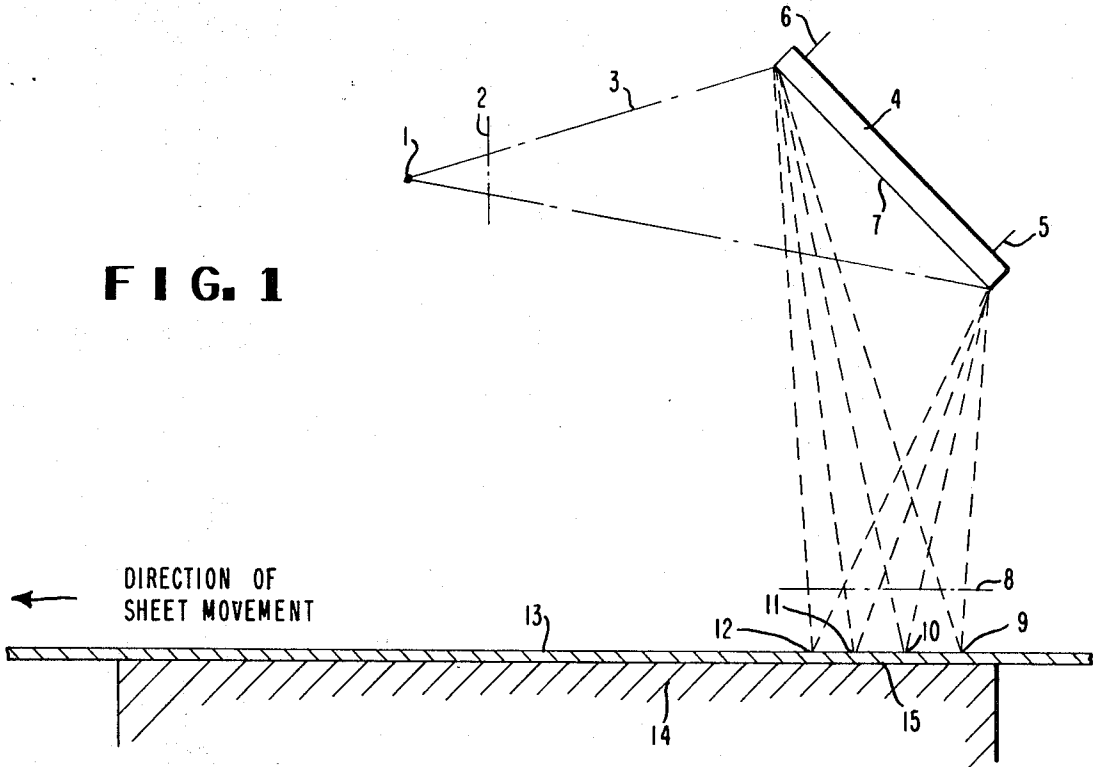
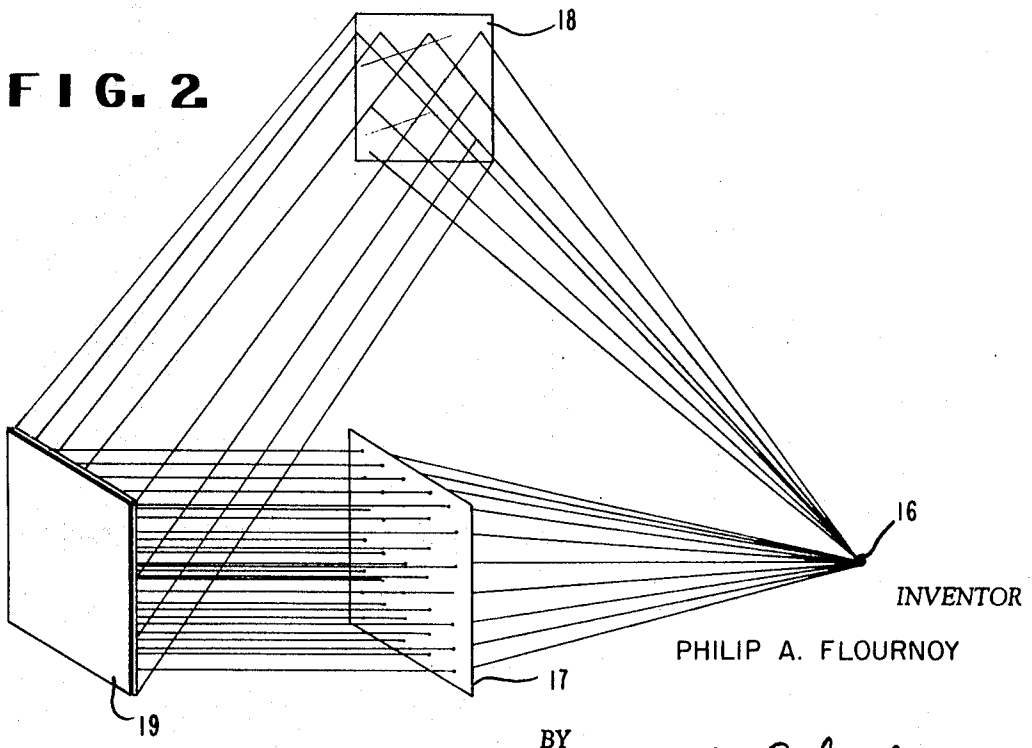


FIG. 2



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APPARATUS AND METHOD FOR PERFORATING SHEET MATERIAL

BACKGROUND OF THE INVENTION

This invention relates to:

A. an apparatus and method for perforating sheet material by means of a laser beam and a reflective hologram; and

B. an apparatus and method for perforating sheet material by means of a plurality of laser beams and a plurality of reflective holograms.

The art of forming perforations in sheet material is known. Some of these methods include forming perforations by the use of drills, tapered punches, punches and dies, needles, hot needles, electrical discharge devices and laser beams. Representative apparatus and methods are described in Proctor U.S. Pat. No. 2,994,617 issued Aug. 1, 1961 (perforating sheet material by means of needle punching); Korgan et al. U.S. Pat. No. 3,017,486 issued Jan. 16, 1962 (perforating sheet material by means of electrical discharges); Meaker et al. U.S. Pat. No. 2,550,366 issued Apr. 24, 1951 (perforating sheet material by means of electrical discharges) and Harding U.S. Pat. No. 3,226,527 issued Dec. 28, 1965 (perforating sheet material by means of a laser beam and an indexing device capable of passing the laser beam back and forth over the surface of the sheet material in a series of parallel rows until an array of the desired number of holes are formed in the sheet material).

There are many disadvantages to the above-mentioned methods. For example, when tapered punches or needles are used for forming perforations, since no material is removed, in some types of sheet material, the perforations may gradually close.

When tapered punches and dies, drills or needles are used for forming perforations, periodic sharpening of the tools, normal damage to the tools (i.e. breaking, bending, etc.), jamming of the perforating mechanism and other operational difficulties cause increased production costs.

When drills, tapered punches, punch and dies, needles or electrical discharge devices are used for forming perforations, it is impossible to obtain small holes. For instance, in the punch and die method, it is difficult to obtain hole sizes as small as 16 mils; rather, the average size is in the range of 30 to 45 mils.

When the prior art laser devices are used, it is possible to form both relatively large and very small perforations in sheet material. However, to form very small perforations, the prior art devices utilize a precise lens which must be placed extremely close to the material to be perforated, in order to focus the laser beam into a very small cone (for example, if one wishes to make perforations that are less than about 15 microns in diameter, the lens would have to be at a distance of about 1 millimeter from the sheet material). This requirement that a lens be used with the prior art laser devices increases the total cost of forming perforations because: (1) the precise focusing lens is often quite expensive, (2) when the laser beam is at certain wavelengths, the focusing lens absorbs appreciable amounts of energy of the laser beam, thus increasing the total power requirements, and (3) the lens must be positioned very close to the sheet material which introduces operational difficulties (that is, for example, sheet material thickness variations or flutter motions due to web transport may cause the sheet material to strike the lens).

Furthermore, if it were desired to use the prior art laser devices to form a large number of very small perforations in the sheet material, difficulty and a high consumption of time would be encountered since the prior art devices utilize an indexing mechanism to pass the laser beam back and forth over the sheet material to thus form an array of perforations. Moreover, if it were desired to form perforations in sheet material that were invisible to the naked eye, this could not be accomplished readily with the prior art devices because even though they are capable of forming holes that by themselves are invisible to the naked eye, since the perforations would be formed in even rows, they would be visible to the naked eye.

Consequently, in view of the foregoing, the need is created for:

1. a device, that with simple modifications, is capable of producing both relatively large and very small perforations in sheet material, and

2. a device, that when so modified to produce very small perforations, can produce said perforations rapidly, and if desired, in a random distribution, without the use of an indexing mechanism or a critical focusing lens.

SUMMARY OF THE INVENTION

According to the present invention there is provided:

A. Apparatus for perforating sheet material by means of a beam emitted from a laser source which comprises:

1. a means for moving the sheet material;

2. a laser source;

3. a reflective hologram, said hologram:

a. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon;

b. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

4. means for causing the high-intensity spot images to impinge upon certain areas of the sheet material for a duration that is greater than the duration of impingement in other areas, said sheet material areas of greater duration of impingement receiving sufficient energy to cause perforations to be formed therein, and said sheet material areas of lesser duration of impingement receiving impingement in amount of from no impingement at all to an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

B. The apparatus defined in (A) wherein in lieu of the single laser source mentioned in part (2) there is a plurality of laser sources and in lieu of the single hologram mentioned in part (3) there is a plurality of holograms.

C. A method for perforating sheet material by means of a beam emitted from a laser source which comprises:

1. moving the sheet material to be perforated, and simultaneously,

2. passing the beam from a laser source onto the surface of a reflective hologram, said hologram:

a. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon;

b. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

3. causing the high-intensity spot images to impinge upon certain areas of the sheet material for a duration that is greater than the duration of impingement in other areas, said sheet material areas of greater duration of impingement receiving sufficient energy to cause perforations to be formed therein, and said sheet material areas of lesser duration of impingement receiving impingement in an amount of from no impingement at all to an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

D. The method defined in (C) wherein in lieu of the single laser source mentioned in part (2) there is a plurality of laser sources; and in lieu of the single hologram mentioned in part (2) there is a plurality of holograms.

As will be apparent from the description that follows, the above mentioned device is capable of producing both relatively large and very small perforations by merely inserting different holograms therein. Moreover, (a) perforations can be produced rapidly, and if desired, in a random distribution, (b) the reflecting hologram absorbs very little, if any, energy from the laser beam, thus resulting in more efficient operation as compared to prior art devices, and (c) no precise focusing lens is required.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention can be understood more clearly by reference to the accompanying drawings in which 14.

FIG. 1 is a schematic representation of several preferred embodiments of the invention and

FIG. 2 shows a method for producing a hologram that is capable of reproducing high-intensity spot images when a beam emitted from a laser source is cast thereon.

Referring to FIG. 1, sheet material 13 is caused to move by sheet material moving means 14. Simultaneously, a beam 3, emitted from a laser source 1, is cast upon a hologram 4, having its surface 7 prepared in such a manner that it will reflect high intensity spot images, 9, 10, 11, 12 onto the moving sheet material 13, when a beam 3 emitted from the laser source 1 is cast thereon. Suitable means for causing the high-intensity spot images to pulsate, so as to cause, with each pulsation, perforations in the sheet material are positioned at locations 1, 2, 5, 6 or 8.

That is, for example, at location 1 there could be positioned a laser source that pulsed at a suitable frequency. This pulsating laser beam would be transformed into pulsating high-intensity spot images when it was reflected from the hologram.

Or, at location 2, there could be situated means for interrupting the laser beam e.g. a shutter or similar type of device) so as to cause the laser beam to pulsate. Similarly, as described above, when this pulsating laser beam was reflected from the hologram, it would be transformed into high-intensity spot images.

An alternative pulsating means would be provided by positioning at location 8, a means for interruption the high-intensity spot images e.g. a shutter or similar type of device).

The above three pulsating means will cause the apparatus represented in FIG. 1 to produce substantially even rows of perforations. If it were desired to provide a random distribution of perforations, either of the three means above could be used in conjunction with a means for causing the hologram to vibrate or move in a random motion. For example, a stationary mount could be pivotally attached to one end of the hologram at point 6, and a vibrating means could be attached to the other end of the hologram at point 5, so as to cause the hologram to vibrate.

Another means for causing pulsation of the high-intensity spot images would be to specially prepare the surface of the hologram 4, so that it reflected high-intensity spot images only when the laser beam impinged upon it at certain angles. A stationary mount could be pivotally attached to one end of the hologram at point 6, and a vibrating means could be attached to the other end of the hologram at point 5, so as to cause the hologram to vibrate in such a motion that high-intensity spot images would only be reflected therefrom during certain periods of its movement. Thus, the aforementioned arrangement of a hologram having a specially prepared surface, a pivoted mount and vibrating means would cause the hologram itself to act as a shutter and would cause the high-intensity spot images to pulsate. If the vibrating means caused the hologram to have a regular movement, the perforations formed in the sheet material would be in substantially even rows. However, if the vibrating means caused the hologram to have a random movement then the perforations formed in the sheet material would have a random arrangement.

The above-mentioned means operate by causing the high-intensity spot images to pulsate. Alternative means can be utilized wherein the apparatus of FIG. 1 IS SO CONSTRUCTED THAT THE HIGH-intensity spot images will trace pathways over the surface of the sheet material, certain areas of these pathways to receive a greater duration of impingement from the high-intensity spot images than other areas, said sheet material areas of greater duration of impingement receiving sufficient energy to cause perforations to be formed therein and said sheet material areas of lesser duration of impingement receiving an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

One method for causing the high-intensity spot images to trace the above-mentioned pathways over the surface of the sheet material would be to vibrate the hologram. For example, a stationary mount could be pivotally attached to one end of the hologram at point 6, and a vibrating means could be attached to the other end of the hologram at point 5, so as to cause the hologram to vibrate. If this vibration is in a random motion, the perforations formed in the sheet material will be in a random distribution. If however, the vibration is in a regular motion, the perforations formed in the sheet material will be in a substantially uniform array.

An alternative means for causing the high-intensity spot images to trace the above-mentioned pathways would be to cause the sheet material to move in jerks. For example, the sheet material moving means 14, could be modified so as to cause this type of motion. This method would form a substantially uniform array in the sheet material. If it were desired to form a random distribution of perforations in the sheet material, it could be moved in jerks while it simultaneously passed over an irregular surface, located at 15.

All of the above-described devices utilize a single hologram and laser source, which would be suitable for perforating sheet material having a width about equal to that of the hologram. For example, if the sheet material to be perforated is about 1 foot in width, a hologram that has dimensions of about 1 foot by about 1 foot, placed about 1 foot from the moving sheet material, would be a satisfactory satisfactory arrangement for forming perforations therein.

However, if the sheet material is wider than about 1 foot, due to possible difficulties in producing holograms larger than about 1 square, it may be desirable to use a plurality of holograms, attached to each other, so as to form a rectangular hologram, that is about as long as the width of the sheet to be perforated. A sufficient number of laser sources could then be so arranged that their beams impinged upon the reflective rectangular hologram.

Any suitable laser source can be employed in this invention. Normally, it will be selected (1) so that it has a sufficient total power output to form the desired number of perforations in the sheet material and (2) so that it emits energy at a wavelength that is absorbed by the material to be perforated and is capable of forming perforations of the desired size.

As is known in the art, there are many methods for making holograms. Explained below are two methods for making holograms which will reproduce high-intensity spot images.

Referring to FIG. 2, the process represented therein embodies a laser source 16, a perforated plate 17, a mirror 18 and a photographic plate 19. In operation, the laser source 16, emits beams which impinge upon the perforated plate 17 and the mirror 18. Of the total quantity of beams which impinge upon the perforated plate 17, only those which pass through the perforations are transmitted to the photographic plate 19. Substantially all of the beams which strike the mirror 18, however, are reflected onto the photographic plate 19. When the beams from the mirror 18, and the perforated plate 17 impinge upon the photographic plate 19, they form an interference pattern. These laser beams are allowed to impinge upon the photographic plate 19 for a time that is sufficient to expose it.

Following the above exposure, the photographic plate 19 is developed using standard developing techniques. Thereafter, the developed photographic plate is coated with silver or a similar highly reflective metal or material to form a finished reflective hologram.

This finished hologram can then be used to reproduce high-intensity spot images by either (a) causing a laser beam which has a wavelength that is the same as that of the laser which originally produced the exposed photographic plate to impinge upon the hologram surface, or (b) causing a laser beam which has a wavelength which is different from that of the original laser beam which produced the exposed photographic plate to impinge upon the hologram surface. AS an example of method (b), one could use a laser source which emitted a beam having a wavelength in the infrared range (about 10.6

microns). When these beams impinged upon the hologram, produced with a laser emitting beams in the visible spectrum, high-intensity spot images would be reproduced. However, due to the method of production of the hologram, the high intensity spot images probably could not readily produce perforations smaller than about 1,000 microns.

If it were desired to produce perforations that were smaller than about 1,000 microns, and it were desired to use a laser source which emitted a beam having a wavelength within the infrared spectrum, one would have to produce a hologram by using a laser which emitted a beam having a wavelength in the infrared range. Because of this, in lieu of the photographic plate 19 shown in FIG. 2, one would have to use a plate which was coated with a material that was sensitive to laser beams within the infrared spectrum. After its exposure by using a technique similar to that shown in FIG. 2, the plate would be developed by using a method that was suited to the special coating thereon. The developed plate would then be coated with silver or a similar highly reflective metal or material to produce a finished hologram.

The invention will be understood more clearly by reference to the following example.

EXAMPLE 1

It is desired to form 14,000 perforations per square inch, such perforations being approximately 10 microns in diameter, in the following polymeric sheet material:

thickness of sheet material = 0.001 inch

width of sheet material = 60 inches

film speed = 12 inches per second

energy required to form 1 perforation in the sheet material = 10^{14} joules

Therefore, a laser having a total power output (or several lasers having a combined power output) of about 1,010 watts would be suitable to form these perforations.

A $\text{CO}_2\text{-N}_2\text{-He}$ laser which emits energy at about 10.6 microns would be suitable to form these perforations since the 10.6 micron wavelength is in the region of high energy absorption for most polymeric materials.

To provide a reasonable spacing between the hologram and the moving sheet material and to maintain a depth of focus which would not be adversely affected by sheet material thickness variations or small flutter motions due to sheet material transport, a 12-inch-square hologram located about 12 inches from the sheet material would be satisfactory. Five of these holograms could be attached to each other to form a hologram 60 inches by 12 inches which would be placed over the moving sheet material in such a position that it would reflect high-intensity spot images onto the entire width of the moving sheet as it passed thereunder. Each hologram would have its surface prepared in such a manner that it would reproduce 40 randomly spaced perforations each time a laser beam was cast thereon.

The production of perforations can be accomplished with an arrangement shown schematically in FIG. 1. Shown is an edge view of the equipment. A total of five beams, emitted from a single laser source having the total power required, or from five sources, each having one-fifth of the total power required, are caused to diverge to illuminate 1 foot by 1 foot sections of the reflecting hologram. The reflected energy will form a real image (shaped in the form of a spot) of the 40 randomly spaced perforations recorded on each hologram. This image will be formed at the film surface as shown and since there are five beams and five holograms in a linear array across the width of the film (normal to the plane of the figure), there will be 200 perforations produced in the film with each pulse of energy from the laser. Pulsating the laser at 50 kilocycles per second thus produces 10^7 perforations per second, which with the film moving at 1 foot per second would produce 2×10^8 perforations per square foot or approximately 14,000 perforations per square inch. Vibration of the holograms (using for example a vibrating means located at 5 and a

pivotal mount located at 6) would randomize the position of the images formed with each pulse which would thereby create perforations in a random distribution which would be invisible to the naked eye.

The invention claimed is:

1. Apparatus for perforating sheet material by means of a beam emitted from a laser source which comprises:

A. a means for moving the sheet material;

B. a laser source

C. a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon; and

2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

D. means for causing the high-intensity spot images to impinge upon certain areas of the sheet material for a duration that is greater than the duration of impingement in other areas, said sheet material areas of greater duration of impingement receiving sufficient energy to cause perforations to be formed therein, and said sheet material areas of lesser duration of impingement receiving impingement in the amount of from no impingement at all to an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

2. Apparatus for perforating sheet material by means of a beam emitted from a laser source which comprises:

A. a means for moving the sheet material;

B. a laser source;

C. a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon; and

2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

D. means for causing the high-intensity spot images to pulsate at a suitable frequency, so as to cause, with each pulsation, perforations to be formed in the sheet material.

3. The apparatus of claim 2 wherein the means for causing the high-intensity spot images to pulsate is a laser source which emits a pulsating beam.

4. The apparatus of claim 2 wherein the means for causing the high-intensity spot images to pulsate is a laser source which emits a beam that pulsates at a rate of greater than 1 kilocycle per second.

5. The apparatus of claim 2 wherein the means for causing the high-intensity spot images to pulsate is a laser source which emits a beam having a wavelength that is absorbed readily by the material to be perforated and pulsates at a rate of greater than 1 kilocycle per second.

6. The apparatus of claim 2 wherein the means for causing the high-intensity spot images to pulsate is a $\text{CO}_2\text{-N}_2\text{-He}$ infrared gas laser which emits a beam having a wavelength of about 10.6 microns and pulsates at a rate of greater than 1 kilocycle per second.

7. The apparatus of claim 2 wherein in lieu of the single laser source mentioned in part (B) there is a plurality of laser sources; and in lieu of the single hologram mentioned in part (C) there is a plurality of holograms.

8. Apparatus for perforating sheet material by means of a beam emitted from a laser source which comprises:

A. a means for moving the sheet material;

B. a laser source;

C. a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon; and

2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

D. a means capable of causing the hologram to vibrate, so as to cause the surface thereof to cast a random distribution of high-intensity spot images onto the sheet material; and

E. a means for causing the random distribution of high-intensity spot images to pulsate at a suitable frequency, so as to cause, with each pulsation, a random distribution of perforations in the sheet material.

9. The apparatus of claim 8 wherein the means for causing the high-intensity spot images to pulsate is a laser source which emits a pulsating beam.

10. The apparatus of claim 8 wherein the means for causing the high-intensity spot images to pulsate is a laser source which emits a beam that pulsates at a rate of greater than 1 kilocycle per second.

11. The apparatus of claim 8 wherein the means for causing the high-intensity spot images to pulsate is a laser source which emits a beam having a wavelength that is absorbed readily by the material to be perforated and pulsates at a rate of greater than 1 kilocycle per second.

12. The apparatus of claim 8 wherein the means for causing the high-intensity spot images to pulsate is a CO₂-N₂-He infrared gas laser which emits a beam having a wavelength of about 10.6 microns and pulsates at a rate of greater than 1 kilocycle per second.

13. The apparatus of claim 8 wherein in lieu of the single laser source mentioned in part (B) there is a plurality of laser sources; and in lieu of the single hologram mentioned in part (C) there is a plurality of holograms.

14. The apparatus of claim 8 wherein the means for causing the hologram to vibrate is comprised of a stationary mount pivotally attached to one end of the hologram, and a vibrating means attached to that end of the hologram where the mount is not attached.

15. Apparatus for perforating sheet material by means of a beam emitted from a laser source which comprises:

A. a means for moving the sheet material;

B. a laser source;

C. a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon; and
2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

D. means for causing the high-intensity hole images to trace pathways over the surface of the sheet material, certain areas of these pathways to receive a greater duration of impingement from the high-intensity spot images than other areas, said sheet material areas of greater duration of impingement receiving sufficient energy to cause perforations to be formed therein and said sheet material areas of lesser duration of impingement receiving an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

16. The apparatus of claim 15 wherein in lieu of the single laser source mentioned in part (B) there is a plurality of laser sources; and in lieu of the single hologram mentioned in part (C) there is a plurality of holograms.

17. A method for perforation sheet material by means of a beam emitted from a laser source which comprises:

A. moving the sheet material to be perforated, and simultaneously;

B. passing the beam from a laser source onto the surface of a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam emitted from the laser source is cast thereon;
2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

C. causing the high-intensity spot images to impinge upon certain areas of the sheet material for a duration that is greater than the duration of impingement in other areas, said sheet material areas of greater duration of impingement receiving sufficient energy to cause perforations to be formed therein, and said sheet material areas of lesser duration of impingement receiving impingement in the

amount of from no impingement at all to an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

18. The method of claim 17 wherein in lieu of the single laser source mentioned in part (B) there is a plurality of laser sources; and in lieu of the single hologram mentioned in part (B) there is a plurality of holograms.

19. A method of perforating sheet material by means of a beam emitter from a laser source which comprises:

A. moving the sheet material to be perforated, and simultaneously;

B. passing the beam from a laser source onto the surface of a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam from the laser source is cast thereon;
2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

C. causing the high-intensity spot images to pulsate, thereby forming, with each pulsation, perforations in the sheet material.

20. The method of claim 19 wherein a pulsating beam emitted from a laser source is used for causing pulsation of the high-intensity spot images.

21. The method of claim 19 wherein a beam pulsating at a rate of greater than 1 kilocycle per second, which is emitted from a laser source, is used for causing pulsation of the high-intensity spot images.

22. The method of claim 21 wherein the pulsating beam emitted from the laser source has a wavelength that is absorbed readily by the material to be perforated.

23. The method of claim 21 wherein the laser source is a CO₂-N₂-He infrared gas laser which emits a beam having a wavelength of about 10.6 microns.

24. A method for perforating sheet material by means of a beam emitted from a laser source which comprises:

A. moving the sheet material to be perforated, and simultaneously

B. passing the beam from a laser source onto the surface of a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam from the laser source is cast thereon; and
2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and

C. causing the hologram to vibrate, thereby resulting in the surface thereof casting a random distribution of high-intensity spot images onto the sheet material; and

D. causing the high-intensity spot images to pulsate, thereby forming, with each pulsation, a random distribution of perforations in the sheet material.

25. The method of claim 24 wherein a pulsating beam emitted from a laser source is used for causing pulsation of the high-intensity spot images.

26. The method of claim 24 wherein a beam pulsating at a rate of greater than 1 kilocycle per second, which is emitted from the laser source, is used for causing pulsation of the high-intensity spot images.

27. The method of claim 26 wherein the pulsating beam emitted from the laser source has a wavelength that is absorbed readily by the material to be perforated.

28. The method of claim 26 wherein the laser source is CO₂-N₂-He infrared gas laser which emits a beam having a wavelength of about 10.6 microns.

29. A method for perforating sheet material by means of a beam emitted from a laser source which comprises:

A. moving the sheet material to be perforated, and simultaneously;

B. passing the beam from a laser source onto the surface of a reflective hologram, said hologram:

1. having its surface prepared in such a manner that it will reflect high-intensity spot images when a beam from the laser source is cast thereon;

2. being positioned so that it will reflect the high-intensity spot images onto the sheet material; and
- C. causing the high-intensity spot images to trace pathways over the surface of the sheet material, certain areas of these pathways to receive a greater duration of impingement from the high-intensity spot images than other areas, said sheet material areas of greater duration of

impingement receiving sufficient energy to cause perforations to be formed therein and said sheet material areas of lesser duration of impingement receiving an amount of impingement that contains less than the amount of energy required to perforate the sheet material.

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