Sept. 4, 1973 T. S. GRACZYK 3,756,880

ULTRASONIC PERFORATING A SHEET OF FILM, PAPER OR THE LIKE, WITH CHIP REMOVAL

Filed March 19, 1971

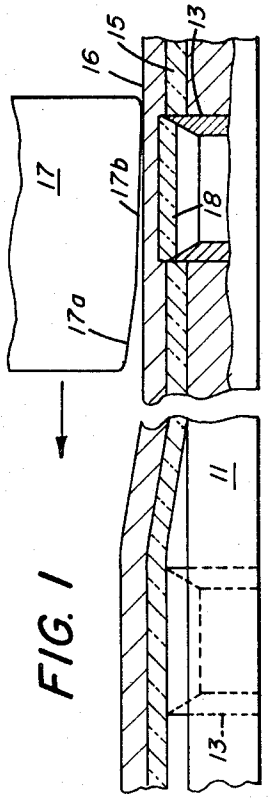

FIG. 1

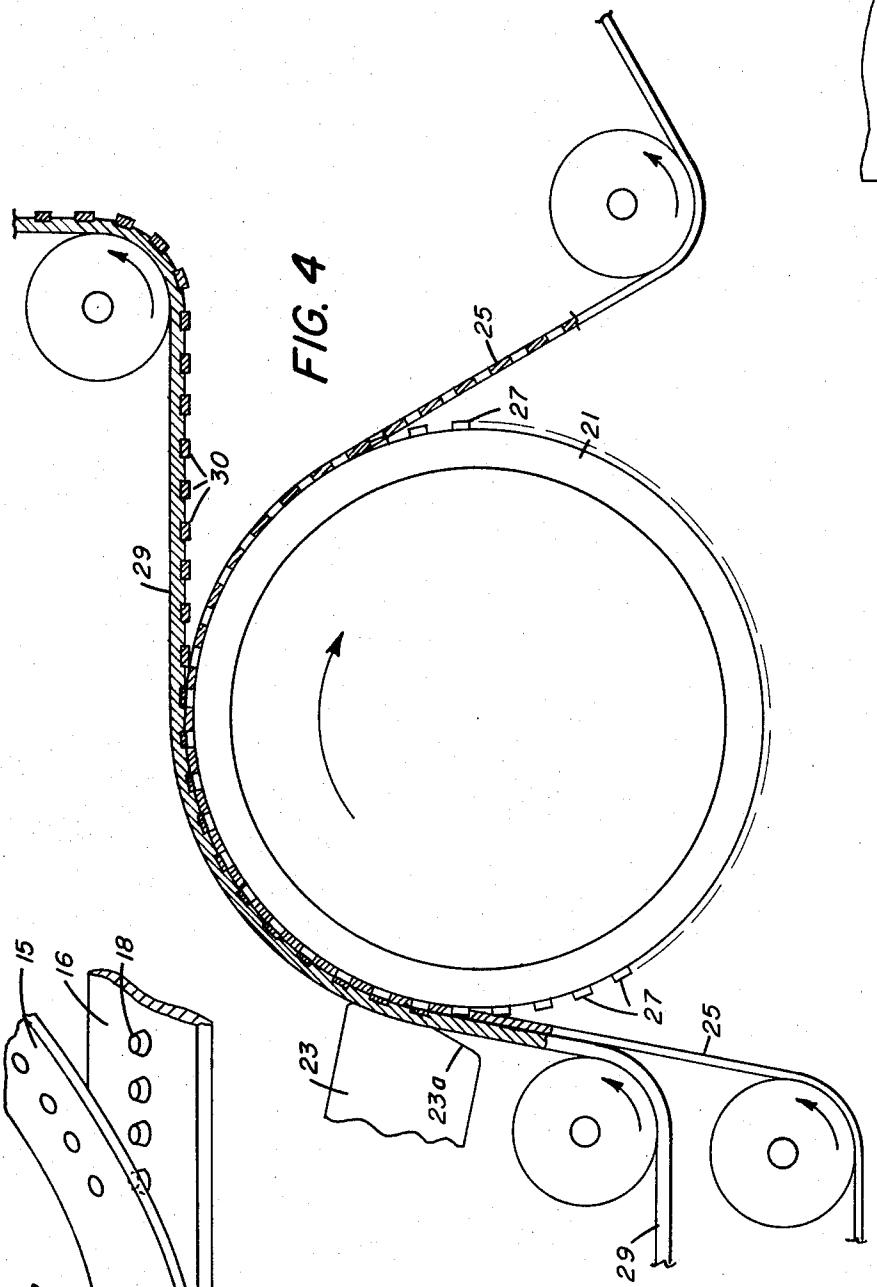

FIG. 4

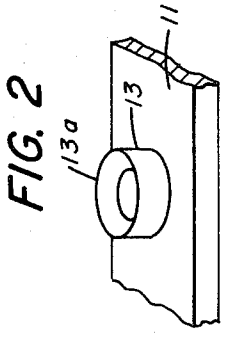

FIG. 2

FIG. 3

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United States Patent Office 3,756,880
Patented Sept. 4, 1973

3,756,880

ULTRASONIC PERFORATING A SHEET OF FILM, PAPER OR THE LIKE, WITH CHIP REMOVAL

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Filed Mar. 19, 1971, Ser. No. 126,163
Int. Cl. B32b *31/16;* B26d *7/06*
U.S. Cl. 156—73 7 Claims

ABSTRACT OF THE DISCLOSURE

A hole is punched through a sheet of photographic film or paper by positioning the sheet with one side in contact with a hollow punch, and applying ultrasonic energy to the opposite side to force the punch through the sheet. A long web of such material can be passed continuously past an ultrasonic horn while a series of punches are successively brought into register with the horn to pierce a series of spaced holes. Such a series of punches can be carried by a rotating cylindrical anvil over which the web is passing. Cores or chips from the holes are removed by causing them to adhere to a secondary sheet or web which is in contact with the sheet or web being perforated, adherence being assured by the ultrasonic vibration which soften thermoplastic material of either the chips or the secondary sheet.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to a novel method of and apparatus for perforating a sheet of material such as photographic film or paper, or similar material.

The prior art

In the past, webs of such material (for example motion picture film) have been perforated along one or both edges by the intermittent operation of a punch and die set, with periodic indexing of the web. Other methods for perforation have involved laser beams and electrical discharge means. The most commonly used are punch and die combinations because of the great accuracy that can be obtained. However, the speed of operation is lower than desirable, intermittent movement of the film rather than continuous movement is required, a substantial quantity of undesirable dust is created, and separation of coated layers from one another may occur adjacent each hole when punching photographic film or paper. Moreover, the conventional punch and die sets require expensive precision grinding (theoretically zero tolerance) for tight fit. Both parts are subject to considerable stress and wear as they punch with high force into the hard, unsoftened material and rub against hard surfaces. Consequently, both parts have to be frequently reground or replaced at considerable cost.

In the past some difficulty has been encountered in removing the cores or chips which have been punched out of the web. In some cases it has been proposed that they remain within the hollow punch (as in U.S. Pat. 1,389, 645); and in others they have been deposited in cavities in a secondary web which travels along with and under the primary web being perforated (as in U.S. Pat. 2,018, 366).

SUMMARY OF THE INVENTION

In accordance with the present invention the disadvantages discussed above have been overcome by positioning a sheet of film or paper with one side thereof in contact with a punch, and then applying ultrasonic energy to the opposite side of the sheet to force the punch through the sheet. Ultrasonic energy is applied by a horn vibrating at between about 20 and about 40 kHz, or more, and exerting a mechanical force against the sheet while also heating it locally at the interface with the punch so as to soften the material and reduce energy requirements, while also reducing the possibility of dust being formed. The procedural steps just described apply to the perforation of a continuously moving web which is passing across the ultrasonic horn while a series of accurately spaced punches are successively brought into contact with the opposite side of the web. The speed of operation can be considerably higher than that of conventional perforators.

In order to remove the chips or cores, I position a secondary imperforate sheet or web on the primary sheet or web being perforated, betwen the ultrasonic horn and the die. At least one of the sheets should have at least a surface comprising a thermoplastic adhesive resin, and advantageously should be mainly composed of such a resin, as in photographic film, so that the core or chip adheres to the secondary sheet as a result of the ultrasonic vibrations which soften the thermoplastic resin. Thereafter, the two sheets are separated from one another, with the cleanly perforated primary sheet travelling in one direction and the secondary sheet carrying the adherent chips or cores travelling in a different direction.

THE DRAWINGS

The principles of the invention will become apparent from the following description having reference to the accompanying drawing wherein:

FIG. 1 is a vertical sectional view, partly in side elevation, showing on an exaggerated scale an arrangement of apparatus for ultrasonically perforating one or more holes in a sheet of material;

FIG. 2 is a perspective view showing a single hollow punch useful for performing the invention;

FIG. 3 is a perspective view showing a perforated primary sheet in relation to the secondary sheet carrying the removed cores; and

FIG. 4 is a side elevational view schematically showing an apparatus for continuously and repetitively ultrasonically perforating a series of accurately spaced holes through a continuously moving long web of material.

THE SPECIFIC EMBODIMENTS

Referring to FIGS. 1 and 2 there is shown an anvil **11** of a dense rigid material such as steel or other metal, having hollow punches or studs **13** mounted within bores therein and protruding above the top surface of the anvil by a distance equal to, or slightly greater than, the thickness of primary sheet **15**, to be perforated. A secondary sheet **16** is positioned on top of sheet **15** for the purpose of carrying away the chip or core **18** which is removed from sheet **15**. An ultrasonic horn **17** is positioned with its bottom surface adjacent the top side of web **16**, so that when horn **17** is vibrated rapidly up and down by an ultrasonic transducer of a type which is well known, the horn forces sheets **16** and **15** down toward punch **13** while at the same time heating the sheet **15** at its interface with punch **13**, thus forming a hole therein by cutting out a core or chip **18**.

When a single hole is to be perforated, horn **17** is stationary. When a plurality of holes are to be perforated relative movement between horn **17** and the sheets **15** and **16** across successive punches **13** can be effected in any desired way, as by moving the horn **17** in the direction shown by the arrow, or by moving the anvil and sheets under the horn **17**. To avoid damage to the sheets during such movement, one edge of horn **17** is chamfered at **17***a*; and it is also advantageous for the bottom surface **17***b* of the horn to be flat with the plane thereof inclined slightly away from the flat surface of anvil **11** in the direction of advance of the horn relative to the anvil, say at a 1–1.5°

acute angle, thus reducing friction between the horn and sheet **16** as the horn passes progressively over the leading edge and then the trailing edge of punch **13**.

Ultrasonic transducers suitable for carrying out this operation are well known, and have been described in numerous patents such as U.S. 3,495,104 and 3,022,814.

Generally, such transducers vibrate at a frequency of up to 80 kHz., e.g. 20 or 40 kHz., and may have an amplitude of between .001 and .005 inch, more or less. The transducer generally is carried by a suitable support (not shown) which permits the horn **17** to float rather than being rigidly mounted, thereby permitting the horn to drop down slightly as sheet **15** is forced over punches **13**. However, even with a rigidly mounted transducer, the excursion of the end of horn **17** can be relied upon to perforate the web.

Punch **13** can have any desired shape so that its open end will punch holes of circular, rectangular or other shape as desired. Advantageously the punch is externally cylindrical, is hollow, and is internally bevelled to provide a frustoconical internal wall, say with an included angle of about 30°, and a sharp cutting edge **13***a* as shown in FIG. 2. The internal bevel assures that the core **18** will be pressed against secondary web **16** to adhere thereto.

My novel perforating method has been successfully used for perforating holes of various shapes in acetate type and poly(ethylene terephthalate) type photographic film **15** ranging from 2.5 to 10 mils thickness, using paper **16** of thickness in the same range. Examples of holes punched are circular holes of 100 mils diameter, and rectangular holes 57 x 80 mils. The sharp edge punch **13** penetrates about 2 mils into the paper, and core **18** is welded thereto by the ultrasonic energy acting on the inclined wall of the punch.

FIG. 3 shows the appearance of webs **15** and **16**, respectively, after the holes have been punched in web **15** and the frustoconical chips or cores **18** adhere to the web **16** for subsequent removal therewith.

When employing the principles described above for perforating a long web by effecting relative movement between a horn and the web, such as a web of photographic film or paper, rapid and continuous operation is desired. This can be secured with the apparatus shown in FIG. 4 wherein a steel or other metal anvil **21** is cylindrical in shape and is mounted for continuous rotation adjacent the end of an ultrasonic horn **23**, to carry a long web **25** of photographic film or paper continuously across the horn.

The anvil **21** carries a series of equally spaced radially extending hollow punches **27** which are successively brought into register with horn **23** to perforate long primary web **25** as it passes continuously across energized horn **23**. At the same time there is passed between the web **25** and the horn **23** a secondary web **29** of material such as paper for the purpose of removing the cores or chips **30** away from film **25**. Webs **25** and **29** are transported over conventional rollers driven by conventional drive mechanisms which are so positioned as to bring the two webs together from spaced positions, and subsequently to separate the webs from one another so as to carry the chips away. Anvil **21** can be driven directly, or can be driven by the motion of webs **25** and **29**.

The end of horn **23** is slightly curved to conform with the surface of anvil **21**, and has a chamfered corner **23***a* to assure that damage to the webs will be avoided.

Instead of employing a stationary horn **23**, perforating may be accomplished with a rotatable cylindrical ultrasonic horn of the type shown in U.S. Pat. 3,210,864 of T. B. Jones et al. entitled "Method and Apparatus for Ultrasonic Welding."

The principles of the invention can be applied to sheet or web materials of many types as long as one of the contacting surfaces of superposed sheets or webs comprises a thermoplastic adhesive material which is softened by the ultrasonic vibrations and causes chips from the primary sheet to adhere to the secondary sheet. Generally the primary sheets **15** and **25** comprise a thermoplastic photographic film such as cellulose acetate, polyethylene, polypropylene, polyvinyl acetate, polyvinyl choride, a copoymer of polyvinyl acetate and chloride, polyvinylidene chloride or poly(ethylene terephthalate). The secondary sheets **16** and **29** generally are paper. Alternatively, either or both of the sheets can comprise a non thermoplastic material such as metal or paper, having a thin coating of a thermoplastic resin on the surface which contacts the other sheet, for example, polyethylene or any of the other thermoplastic materials mentioned above.

The ultrasonic perforating method as described above provides important advantages. It requires only the punch (or hollow cutting stud), without a precision ground die.

The stress and friction between the punch and the material being worked, are very significantly reduced due to the fact that the ultrasonic energy induces transient plasticity in this material. The punch advances into the presoftened film progressively from the leading to the trailing surface of the hole being perforated, as the high frequency slightly inclined vibrating horn surface slides over.

Thus, the punch works on presoftened materials only and never touches any hard metal surfaces. (There is soft separation tape acting as a buffer between the punch and the metal tip of the ultrasonic transducer.) The horn slides on the buffer material only, friction is reduced to a minimum due to the high frequency vibrations, and the horn's surface remains essentially unchanged for life.

In conclusion, the ultrasonic perforator of this invention very significantly reduces tool wear, minimizes built-in stresses in the perforated material, is simpler to install, and requires less maintenance than punch and die devices.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. A method for ultrasonically perforating a first sheet of material by removing a chip therefrom and carrying said chip away on a second sheet, at least one of said sheets having at least a surface thereof comprising a thermoplastic resin, said method comprising

providing at least one perforating punch;

positioning said first sheet on said perforating punch;

positioning said second sheet with one surface thereof on said first sheet; said thermoplastic surface of one sheet being in contact with the other sheet;

positioning an ultrasonic horn adjacent the opposite surface of said second sheet and in register with said perforating punch;

applying ultrasonic energy by said ultrasonic horn to an area on said opposite surface of said second sheet over said punch thereby causing said punch to penetrate through said first sheet removing a chip therefrom, and concurrently softening said thermoplastic surface causing said chip to adhere to said second sheet; and

separating said first sheet from said second sheet and the chip thereon.

2. A method in accordance with claim **1** wherein said thermoplastic resin comprises at least a surface of said first sheet.

3. A method in accordance with claim **2** wherein said first sheet is photographic film and said second sheet is paper.

4. A method in accordance with claim **1** wherein said first sheet is positioned on a plurality of said perforating punches, said method also comprising applying such ultrasonic energy by applying an ultrasonic horn to said second sheet, and effecting relative movement between said horn and said sheets in a direction across said punches.

5. A method in accordance with claim **4** wherein such

relative movement is effected by translating said horn across stationary sheets.

6. A method in accordance with claim 4 wherein such relative movement is effected by translating said sheets and punches across a stationary horn.

7. A method in accordance with claim 6 wherein said punches are translated across said horn by rotation in a circle; and wherein said sheets are webs, said method comprising moving said webs together between said punches and said horn, after separating said webs from one another thereafter.

References Cited

UNITED STATES PATENTS

3,330,026	7/1967	Best et al.	156—73
3,032,463	5/1962	Morgan	156—253

DOUGLAS J. DRUMMOND, Primary Examiner

U.S. Cl. X.R.

83—16, 23; 156—253

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,756,880 Dated September 4, 1973

Inventor(s) Thadeus S. Graczyk

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 5 after "perforation of a" insert--stationary web as well as to the repetitive perforation of a--.

Signed and sealed this 14th day of May 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents