NOTES · AND · NEW TECHNIQUES

REVOLUTION IN DIAMOND CUTTING: LASER SAWING OF DIAMOND CRYSTALS

By David M. Baker

Laser sawing of diamonds is beginning to revolutionize the diamond-cutting industry. Not only does the laser saw offer savings in time and money, but it also enables the cutting of material virtually unworkable by conventional methods and makes available an almost limitless assortment of fancy shapes. This article describes the components and operation of the laser saw, as well as the situations in which it has proved most useful.

The modern technology of the laser (*l*ight *a*mplification by the *s*timulated *e*mission of *r*adiation) has penetrated the ancient art of diamond cutting. The use of lasers represents one of the greatest technological advances for the diamond cutter since the advent of the conventional diamond saw in the 1930s. In the hands of a competent operator, the laser saw can save time and money, and can greatly reduce the risk associated with conventional cutting methods.

The art of laser sawing is, for the most part, a well-kept secret. Although the manufacturers of laser diamond-cutting equipment are careful about releasing statistics on the number of units currently in use in the diamond industry, unofficial sources estimate that there are approximately 15 units in the U.S. and a total of 50 units in operation worldwide. In many cases, diamond cutters with adjacent offices are not aware that their neighbors have laser facilities.

On the basis of information gathered from sources in the diamond-cutting industry and researchers involved with laser technology, this article describes the laser saw and explains how it is used to cut diamonds. The article also discusses those situations in which the laser saw has proved to be invaluable.

THE LASER SAW

The components of the laser saw are illustrated in figure 1. On the right, a large cabinet houses a power amplifier for the laser's flash lamps. These lamps surround the neodymium-doped yttrium aluminum garnet (Nd:YAG) rod, which is enclosed in the smaller metal cabinet that appears in the center of figure 1. Located off to the left outside the first figure are the focusing lens, the x-y platform on which the stone is mounted for passage through the laser beam, and a microscope and television monitor, both of which are used to observe the progress of the laser through the stone (see figure 2).

The laser beam is created as light from the flash lamp excites the neodymium atoms in the YAG crystal host, causing them to give off laser

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Figure 1. The laser saw unit consists of a large cabinet that houses the power amplifier for the flash lamps (on the right), a smaller cabinet that encloses the laser rod (center), and an x-y platform computer (off to the left).

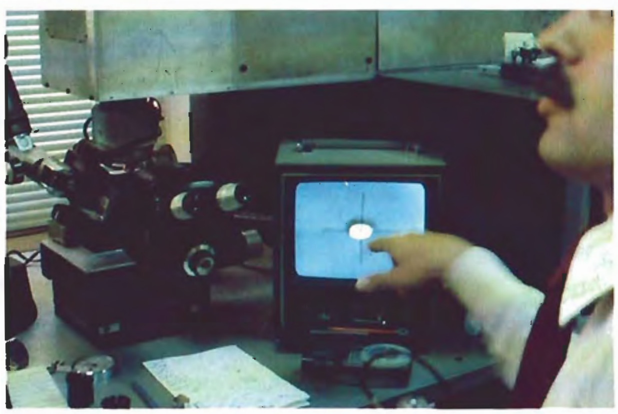

Figure 2. To complete the laser saw unit, this figure shows the x-y platform, the focusing lens, and the microscope and television monitor used to observe the progress of the laser through the stone.

light. This light is emitted from the rod as a parallel beam of a single color. (Actually, the light is invisible, with a wavelength of 10,640 Å in the near infrared region of the spectrum.) A procedure known as Q-switching is used in most diamond-cutting laser saws to increase the intensity of the light beam.

The beam that is emitted from the rod is 1.5 mm in diameter; it subsequently passes through a lens system that increases the diameter to 12 mm. A special mirror reflects the infrared laser light at 90° while allowing the visible light to pass. The reflected light then passes through another lens system that focuses the beam down to a spot 25 microns in diameter on the diamond to be cut.

In contrast to conventional cutting methods, in which the saw as well as the stone being cut move, the beam in laser sawing remains stationary; the cutter needs only to focus further into the stone as the sawing progresses. The diamond is mounted in a dop similar to those used in conventional cutting, and then placed on the x-y platform. The desired cut is preprogrammed into a computer linked to the platform; the platform then moves the diamond through the beam in a back-and-forth motion precisely as determined by the system operator.

Once the beam reaches the stone and the platform begins to move, the sawing starts. At the point where the laser beam strikes the diamond, the temperature is extremely high. As a result, the diamond's molecular structure at this point is converted to graphite on one pass of the beam, with the graphite build-up evaporated or "burned off" on the return pass. It is known that, in air, diamond combustion occurs at 690°C to 875°C. Inquiries made to determine the beam temperature at the point of laser contact remain unanswered.

The width of the cut produced is directly related to the size of the crystal being cut, as a consequence of the V-shaped nature of the beam. Weight loss, approximately 5%–7%, is slightly greater than when a stone is cut by conventional means, and depends on such variables as the size of the crystal and the expertise of the cutter. A representative cutting time would be approximately eight hours for a 10-ct. crystal.

Once the crystal has been completely sawed, the stone looks brackish and opaque. Cleaning by one of several recommended procedures returns the stone to its precut appearance. The saw plane (figure 3) shows minute parallel striations as a result of the movement of the platform.

WHY CUT WITH LASER?

Many diamonds with distorted growth, such as graining or twinning, are virtually impossible to cut by conventional means because of the changes in cleavage and sawing planes they contain. One diamond cutter recently presented a piece of distorted rough in excess of 20 cts. that had been in his possession for over 15 years. It had been carefully sawed and cleaved four or five times over

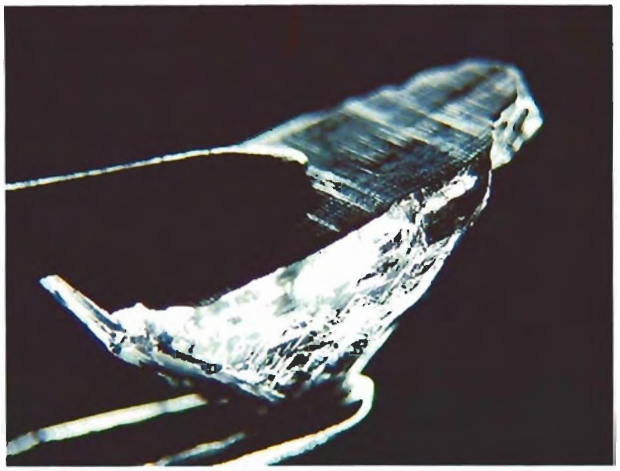

Figure 3. Striated appearance of the laser saw plane.

the years in an attempt to unlock the key to its structure that would allow production of the finest, largest stone possible. A stone such as this can now be sawed by laser without regard for the grain.

The laser saw can also be of help in those situations where the material has included crystals of diamond along the plane selected for sawing. Given our knowledge that diamond has conventional primary sawing directions parallel to the theoretical cube faces and secondary sawing directions parallel to the theoretical dodecahedral faces, and that the crystallographic orientation of the included crystals of diamond is random to the host crystal in most instances, it is evident that the different sawing planes make conventional sawing next to impossible. A diamond cutter using conventional equipment does not "saw" through an included crystal of diamond, he "worries" through it. The vibrations produced when the blade reaches the included crystal can cause the crystal to shatter. Even if the stone does not shatter, the cutting time may easily be twice or three times that of a normal stone, extending into many days or even weeks. With laser technology, this problem is tackled easily and efficiently in a matter of hours.

Other applications of the laser saw include the ability to produce many of the new fancy shapes on the market today—horseheads, oil wells, stars, butterflies, initials, and the like. In addition, there are many industrial applications for laser-cut diamonds: wire dies, surgical instruments, heat sinks, and many others for the electronics and aerospace industries. The potential for unusual cuts is limitless with this method, although it is still somewhat of a mystery how some of these special cuts are polished. The techniques used have remained firm trade secrets.

There are several manufacturers of laser sawing equipment in the U.S. and abroad. Many will provide the buyer with the training needed to become a competent laser saw operator. At this writing, an initial investment of approximately US$75,000 for the laser equipment is required before the first stone is cut. However, lasering services are available on a contract basis.