SYSTEM FOR SLICING SILICON WAFERS

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The newly patented process described here is a system for slicing silicon wafers that has distinct advantages over methods now widely used. The primary advantage of the new system is that it allows the efficient slicing of a number of ingots simultaneously at high speed.

In one of the methods now used, an inside-diameter saw cuts at constant surface speeds, with rapid slicing of one ingot at a time. In a second method, a reciprocating gang saw provides multiple cuts, but in a relatively long time. A third method, a wire technique, marries some of the advantages of the other two methods but has a severely limited service life. Any method that would provide simultaneous fast multiple cuts on several ingots with fewer system breakdowns would be worth considering.

The new cutting concept presented here presents an alternative to the old methods in which the cutting action is performed mechanically, most often with diamond particles that are transported to the cutting zone by a fluid vehicle or have been made an integral part of the blade by plating or impregnation.

The new system uses a multiple or "ganged" band saw, arranged and spaced so that each side, or length, segment of a blade element, or loop, provides a cutting function. Figure 1 illustrates the key functions associated with a single-blade element, operating with a single work station. One end is the driving pulley and the opposite is an idler that is instrumented to maintain tension and detect blade failure. In the event of blade failure, the instrument senses the problem and stops the blade to prevent catastrophic ingot damage. The design would provide for withdrawal of the failed blade while continuing the cutting cycle with a minimum of damage.

Each blade is maintained precisely in position by guides as it enters and leaves each ingot. These expendable guides can be translating ribbons or slowly rotating disks. In the case of rotating disks, as illustrated, the guides rotate one-half revolution during a cutting cycle. This provides fresh, unworn guide material to prevent blade wobble. The guides are designed to be inexpensive and easily replaceable. They are replaced as a unit rather than individually to reduce down time.

The cutting action is performed with a conventional abrasive slurry composed of diamond grit suspended in an oil- or water-based vehicle. The distribution system draws the slurry from the supply reservoir and pumps it to the injection tubes to supply it to each side of each ingot. A flush system is provided at the outer end of the work-station zone. In order to reduce potential damage, a pneumatically driven flushing fluid is provided for removing cutting fluid and cutting debris. This is collected by a drain, filtered, and returned to the reservoir for reuse. This technique would minimize blade wear and damage to the drive system.

The blade is made of a ductile material and is relatively wide and thin in cross-section. It is fabricated without teeth, but during operation the cutting edgc passes over a knurling wheel that deforms or refigures the cutting edge sufficiently to serrate it. The formation of these serrations would increase blade-edge thickness due to lateral deformation of the blade; to correct this, the blade is passed between a pair of cylindrical surface rollers. The blade is thus refigured before each cutting pass (see Figure 2).

The primary purpose of the serrations is to transport the slurry from the distribution system to the cutting surface and to provide egress for chips and debris.

The work station contains the mechanism for holding and advancing the ingot. The figures depict the ingot held in the work station and advanced from below; however, due to the nature of the serrated blades, it may be more effective to utilize an overhead feed with the serrated blade edge on top. The feed system should be instrumented to provide a constant unit load throughout the cutting cycle.

Figure 3 illustrates a plan view of the multiple assembly. The fan pattern provides sufficient space for the drive and tension mechanisms.

The rollers and idlers would be sized to maintain the internal stresses of the blade at a sufficiently low level, resulting in long service life. The fan configuration at each end of the machine would allow a standard blade length. The long blades would reduce wear and permit many cutting cycles before the blade would need replacement.

The number of work stations representing the number of ingots to be sliced will depend upon the installation. The probable practical limits would be a minimum of two or three, which would make the investment uneconomical, to a maximum of 20, beyond which it would be mechanically unwieldy.

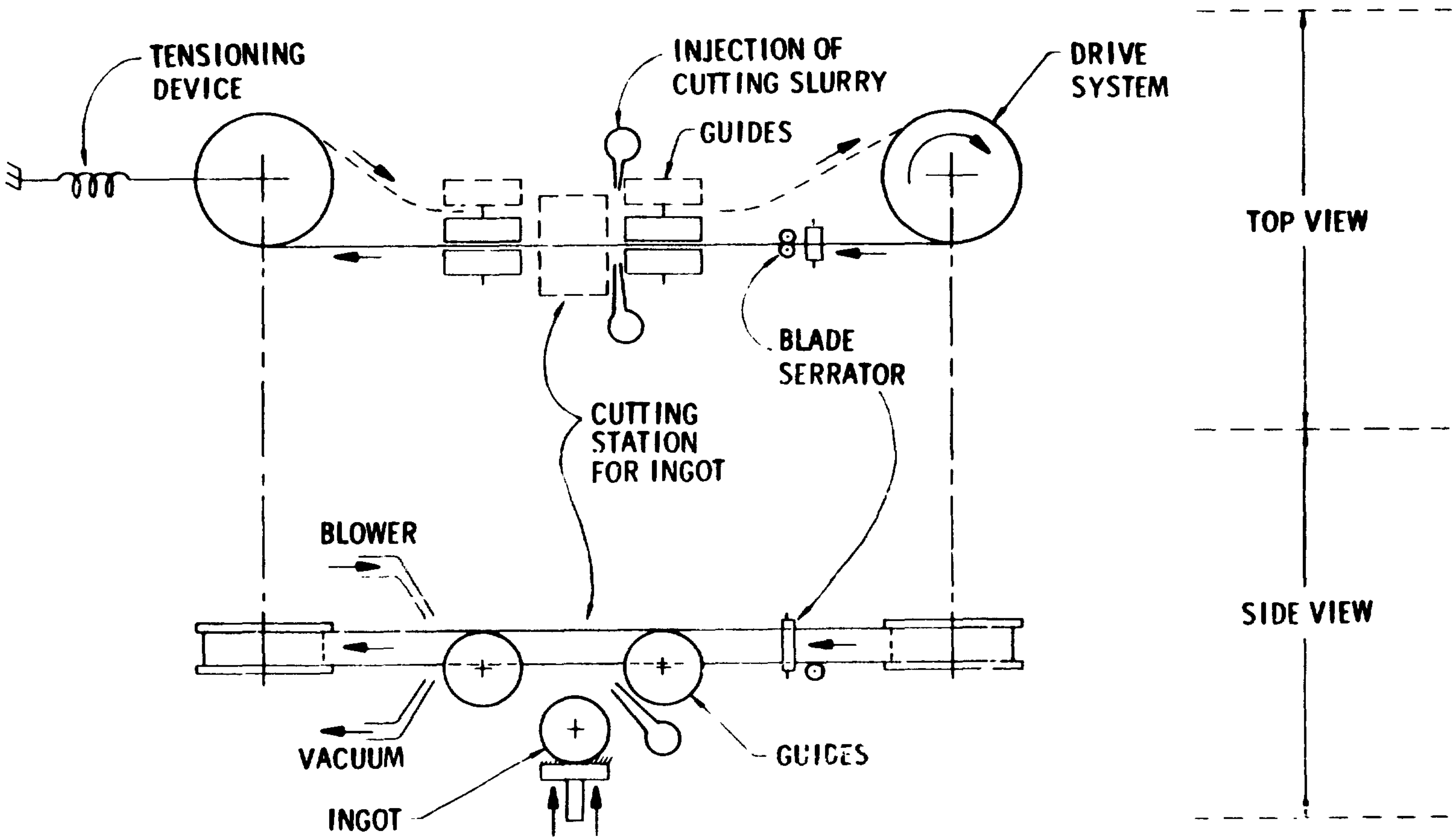

Fig. 1. Representative Single Element (One Direction Only)

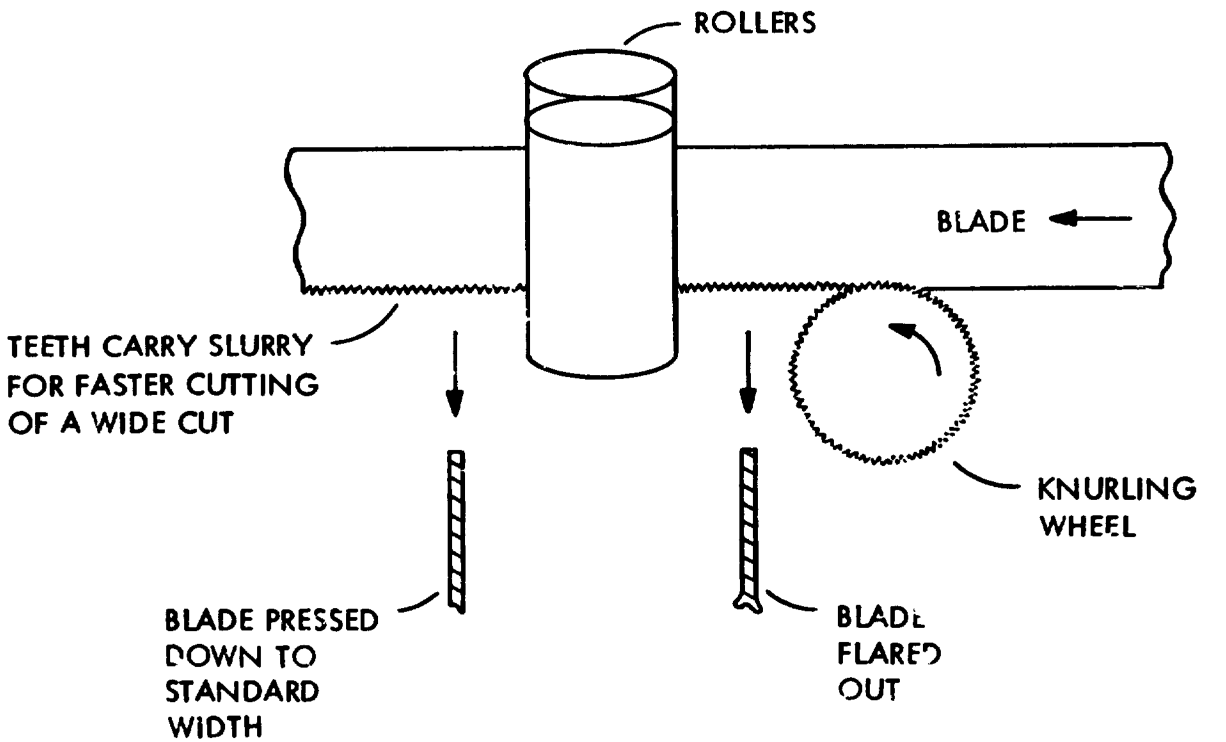

Fig. 2. Blade Serrator

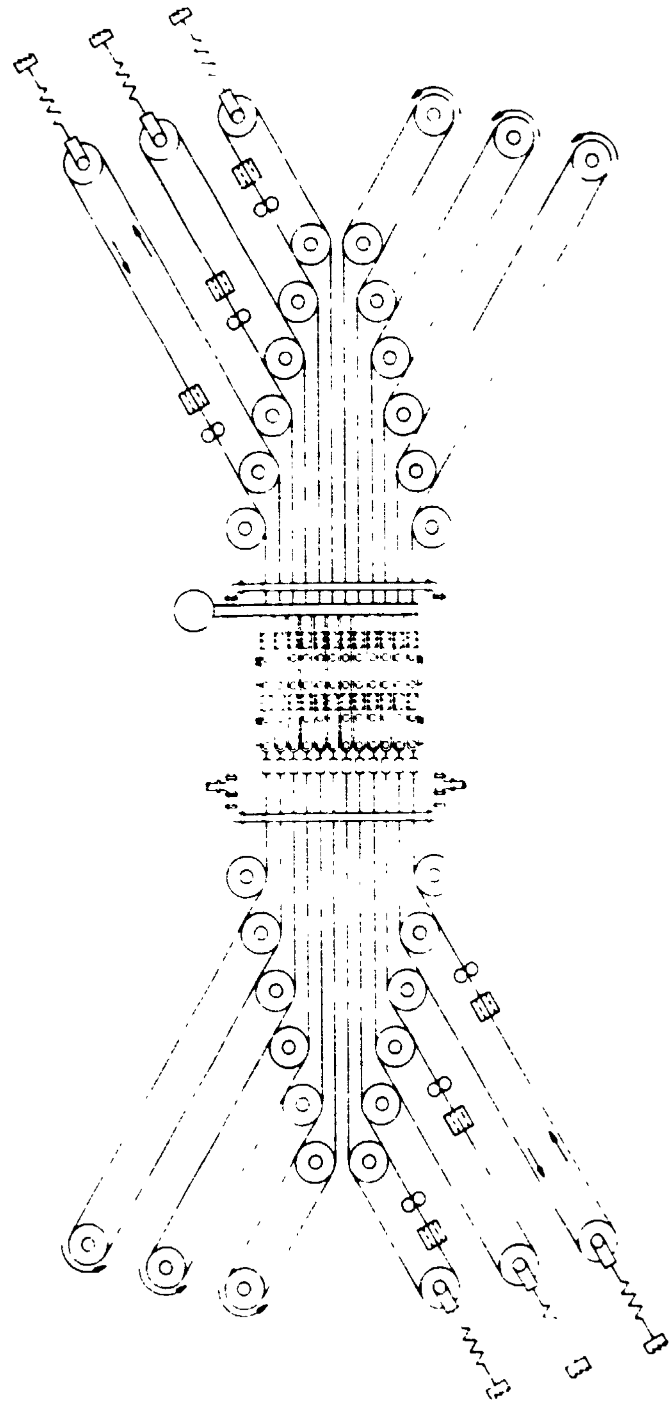

Fig. 3. System for Slicing Silicon Wafers

DISCUSSION

DYER: I see one difficulty. If you have alternating directions you will have a torque n the slice, particularly as it gets toward the bottom, and this may be a difficulty because the friction operating in both directions is going to have a tendency to break the slices off in a torsional fashion.