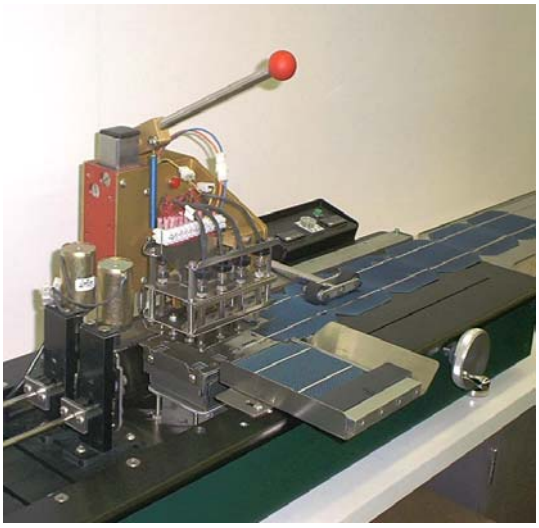
Solar Automation, Inc

Small Scale Photovoltaic Module Manufacturing

Solar Automation has developed a line of production equipment tailored to the needs of small factories that make photovoltaic modules. Currently, most small manufacturing is either labor intensive or under-utilizing expensive automation. Our new equipment is configured to operate where precision is required and throughput optimized. By minimizing complexity, costs are reduced: Initial cost to the factory, cost of maintenance, cost to operate, cost of replacement.

In trade for complexity, the equipment requires that the operator perform a multi-step procedure, similar to machine sewing. Each move by the operator is designed to reduce fatigue; instead of quick repetitive motions, the operator's moves are longer in both distance and time. The operator easily attends to the quality of the output.

CTS20 Combined Tabber Stringer is a radical new approach to producing strings of solar cells. It has been conventional wisdom that production efficiency increases with automation complexity. Solar Automation has created a one-step tabber/stringer that proves a small enterprise need not spend half a million dollars to efficiently solder solar cells. Semi-automatic and low-cost, this equipment is capable of producing machine-accurate strings at the rate of about 15 seconds per cell. The cost is less than one-tenth the capital cost of full automation.



Solar Automation Combined Tabber/Stringer

Model CTS20

Automation versus Cost

Most automation is an exercise in replacing people with machines. We have discovered, as many have, that automating highly repetitious or dangerous tasks is sound business. As the complexity of the task increases so does the cost of automation. When the automation task involves replacing eye/hand co-ordination, the cost climbs vigorously. To automate a task that is relatively simple

for a human operator, such as placing and orienting a solar cell, with a multi-axis servo/vision system, the cost of the equipment increases 10X or more.

Sometimes it does not make sense to automate every process task. This is the approach we took to the design of the CTS20.

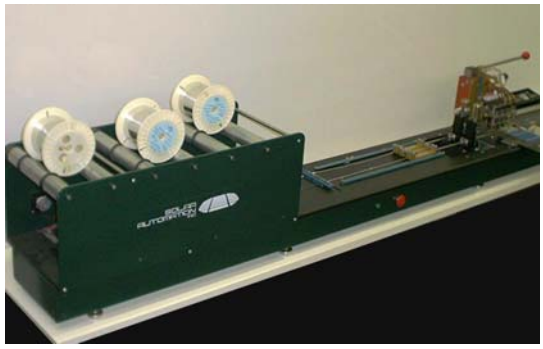
How to Simplify

First we scrutinized every production move, looking for precision and process reliability needs. Soldering solar cells into series circuits must produce accurate ribbon placement, proper cell orientation and required solder-bond quality. The CTS20 mechanizes ribbon placement from spool to solar cell to insure that the ribbon is located accurately.

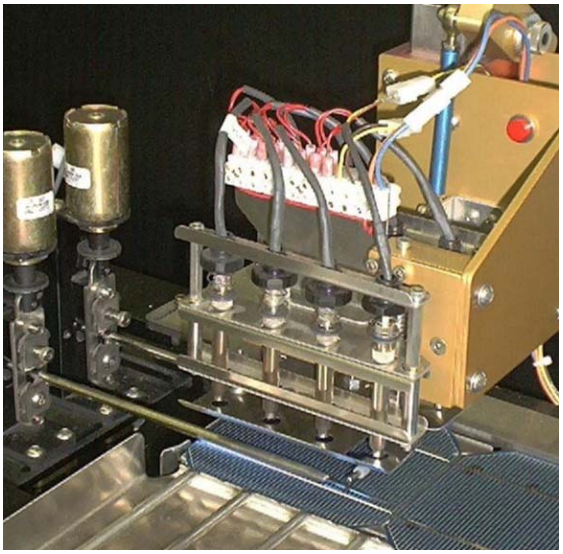
Where a task generally requires an actuator or motor, we asked:

Does it?

We use motors to unwind the ribbon spools, but we allow the operator to manually move the ribbon tips to their accurate location stops. Ribbon lengths are determined by machine setup, so that manual operation always produces predictable precision.



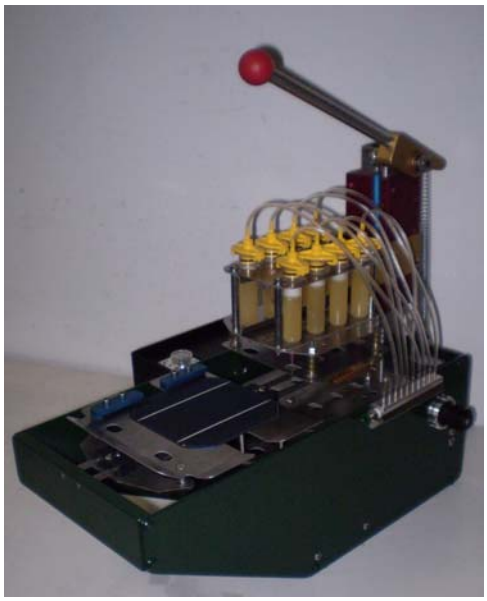
Motorized Ribbon Spools



The soldering process uses conduction heat transfer to apply the least necessary heat as efficiently as possible. We use gentle spring-loaded soldering tips topside and a hot plate below. Each heating group is feedback controlled by a PID (proportional/integral/differential) controller. Most of the heat needed to solder both sides of the cell, emanates from the hot plate. The soldering tips above hold the parts in thermal contact and provide enough heat to insure a proper bond. As a result,

the CTS20 requires less that 1000W to perform soldering. This compares to 4 to 5 kW used in comparable but less efficient machines.

The process is designed for the careful use of flux to minimize excess unwanted chemistry in the laminate. We prefer to use dots of flux at the location of the solder joints. This places flux only where it is needed. **Solar Automation Flux Dispenser model SD2A** provides a method of placing flux on cells. Other methods can be used such as painting or rolling liquid flux onto the cell bus bars.



Solar Automation Flux Dispenser Model SD2A

Individual solder joints are recommended to insure fatigue resistant bonds. Long solder joints set up a severe thermal mismatch stresses and tend to fail at some point. Heat is introduced into the cell generally by the hot plate. When the press is actuated, greater heat flows into the immediate location of each bond. When the press is released, the ribbons remain held in place while the heat loading into the cell is reduced. With ribbons attached to both sides of the cell, the string is advanced to accommodate the next cell.

New thin cells are predictably fragile. When the copper ribbon is soldered to the silicon substrate, the cell will bend as the copper contracts. Hand tabbing cells has become particularly difficult for this reason. The CTS20 attaches the copper ribbons to both sides of the cell simultaneously. As well, each cell is preheated just prior to soldering so that the stresses induced by soldering are both reduced and balanced on both sides of the cell.

For conventional front-contact cells, ribbons are placed atop the cell while trailing tabs from the previously soldered cell lie beneath. This process is very much like tabbing except that a string is created simultaneously.

We recently adapted the CTS20 to string **Back Contact** cells from **Advent Solar** and **Sunpower**. In this case the cells are soldered face down and all connecting material is placed and attached from above.

Solar Automation is in the process of developing a complete small module factory. Using the CTS20 and the SD2A as the foundation, the microfactory is dedicated to bringing feasibility to efficient local manufacturing of an important and emerging product. Supply chains are developing rapidly around the world as shortages of silicon are disappearing. Solar cells will be purchased on the open market along with glass, encapsulant and copper. Electrical terminals can be purchased or contract manufactured. The PV microfactory is intended to preserve a significant portion of the value-added manufacturing activity for the small local business.

With the right tools, small local business can compete with automation or low wage imports.

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