MANAGEMENT

Owners, CEOs

The Multi-Material Analyzer: A New Opportunity for Process Measurement and Control

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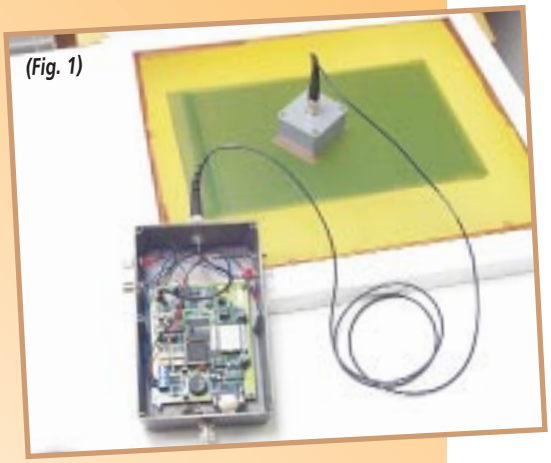
Every once in a while, in the world of R&D, something comes along that seems almost too good to be true. That one piece of the puzzle that makes the whole picture seem to come into sharper focus; the missing information or brilliant idea that launches humanity forward in the effort to first understand and then predict the world around us.

For the ancient architects it was the ability to conceive of and then utilize complex mathematics in a way that resulted in structures so precise and enduring that 20th century theorists are still trying to explain them. The Great Pyramid for example is one of the oldest structures on the face of the earth and yet still stands as a silent testimony to the visionary skills of its builders. Even though this massive construction consists of over two million stones, weighing from one to 20 tons each and covering over 13 acres, the mortar joints are uniformly 1/50 of an inch! The Great Pyramid also lies at the center of gravity of the continents and is in the exact center of all the land area of the world. This results in the earth's land mass being divided into approximately equal quarters with only the Great Pyramid at their point of intersection.

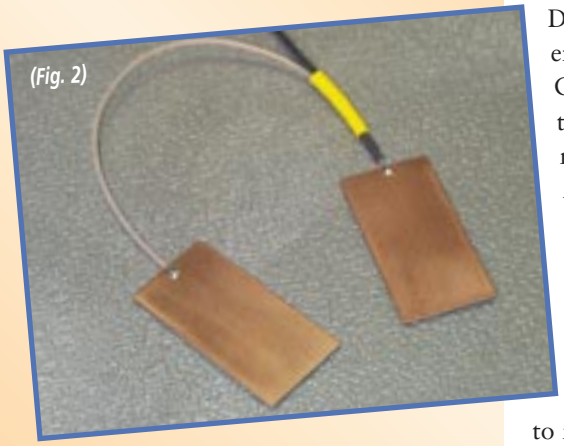
In addition, not only is the Great Pyramid the oldest complex structure on the face of the earth it is also the most accurately oriented to due north, south, east, and west. The best effort of modern man, the Paris Observatory, is six minutes of a degree off true north. By comparison, the ancient builders of the Pyramid were able to orient their "primitive" structure to only three minutes of deviation (and that is after 5000 years of settling, who knows how good it was when they built it). The question begs to be answered, have we really learned anything from these early inventors and their excellent contribution to architectural science?

For the early ocean explorers it was the breakthrough that allowed them to first position themselves latitudinal and then later solving the more complex problem of how to determine their correct longitude. The inability of eighteenth century navigators to determine an east-west position was extremely

Some technology seems almost too good to be true. Learn how to develop your own "measure anything" instrument for improved process control utilizing SPTF research and a low-cost test kit.



PROTOTYPE STENCIL MEASUREMENT INSTRUMENT
Research staff used an experimenter's measurement kit (QProxtm-E2S) and the computer software package that was supplied to design a basic stencil measurement device. The instrument, consisting of a self-contained shielded box and cable with attached probe, performed quite well for a first attempt. With this low cost kit and the ability to custom design probes specific to the application at hand we found that most screen printing materials could be measured effectively.



PADDLE PROBE (FREE FLOATING CONCEPTUAL DESIGN)
• Does Not Work Well Without Rigid Mounting
• Paddle Spacing is Critical

WOOD & COPPER PROBE
(Exploration of the Technology)
• Moisture Absorbent • Difficult Construction • Limited Application

troubling and had resulted in much loss of life in earlier decades. It wasn't until John Harrison[1], a skilled and visionary clockmaker, constructed the first chronometer capable of addressing the complex navigational issues that the problem was solved. His long years of solitary labor overcame obstacles that Newton and Galileo had failed to conquer. And yet it was decades before his contribution gained the wide spread acceptance and position of prominence it deserved largely due to politics and professional jealousy.

History is filled with examples of new ideas, inventions or concepts that have largely been ignored by the masses. A more recent example is that of Dr. W. Edwards Deming[2], the legendary guru of Statistical Process Control, who is credited for the tremendous quality and economic revolution in post war Japan. Although he first offered his expertise to the American auto makers they apparently had better things to do with their time. This resulted in years of trying to catch up to the higher quality/lower cost of the little Japanese imports that seem to run forever.

SPEED IS OF THE ESSENCE

The opportunity to capitalize on new technology or a new idea is never something to be dismissed lightly. In today's competitive market place, if you don't do it someone else certainly will. Ideas and technology have definite periods of opportunity that diminish with time, almost like the cycles of planting and harvest. Anyone who has ever been through the patent search process soon realizes how many distinct people have comparable ideas at almost the same time. The distance between fortune or failure can sometime be measured in minutes when it comes to protecting a new invention before the next guy gets there. In some industries things move so rapidly that patent protection is not even a viable option (new toys or fads are rarely patented) due to fierce competition and the short life cycle of the product.

True technological progress rarely moves forward at a steady predictable pace. Rather it is usually characterized by intermittent bursts of insight, resulting in a surge of new products that were impossible to produce before the breakthrough occurred. These "quantum leaps" although not always foreseen are actually almost inevitable; continuing to increase as we find new ways to tap the global repository of information that has become so easily available to us in the later half of the 20th century.

IDENTIFYING NEW IDEAS

One of the purposes of the Screen Printing Technical Foundation is to help identify new ideas or scientific advances in sectors that may be of potential benefit to the screen printing community. Our mission is not to develop these ideas into full blown finished products ready for the consumer. That would tax SPTF resources to the limit and leave many important areas of investigations undone. The intent here is to establish "proof of concept" studies with the technology that will allow us to recommend possible uses or new applications to screen printing manufacturers. By partnering with manufacturers SPTF can leverage the amount of new ideas that actually reach the industry. In addition, manufacturer specific information and their own beta site testing, will further enrich the final version of the product before it hits the streets.

A recent example of this is the PosiTector 6000 EOC; screen printing's first Electronic Off-Contact Gauge. By identifying alternative technology and applying it in a different way, a tool is brought to the market place that will definitely give printers a "Competitive Advantage" (in some

instances multi-headed press set up times were reduced by as much as 75% using this instrument). Providing better ways to measure key elements of the screen printing process also helps to ensure that it remain profitable in the future.

Another example of breakthrough technology being pursued by SPTF is something called "Charge Transfer Sensing." You have probably all watched one of those late night commercials on television depicting the impossible "do everything device" that you just can't live without. At the risk of sounding like the mad scientist of R&D, I'd like to suggest that by the careful application of this low cost technology it might just be possible for some enterprising manufacturer to produce that "do everything device" for screen printers. A resourceful individual could change the whole approach to process control by developing a working knowledge of this new measurement science.

The detailed explanation of the theory behind "Charge Transfer Sensing"[3] is beyond the scope of this article. However, I do hope to demonstrate how even a basic understanding and a willingness to experiment can produce some rather amazing results. Here's the "Reader's Digest" version of the operating principle and why it's such an experimenter's dream. Charge Transfer Sensing is an original way of using capacitance to measure changes in the electrical conductivity of materials. Through its unique method of processing the different electronic signatures that these materials generate, the ability to sense small changes has been taken to levels unheard of in the past. In addition to the sensitivity increasing by many orders of magnitude, it is also uniquely designed to ignore the effects of most noise or unwanted signals. This offers the experimenter some unusual measurement opportunities. In the world of screen printing there are many materials that change on a regular basis. Some change by design during processing, others change by default due to the effect of the environment, contamination, aging or improper handling. Wouldn't it be nice to know the exact physical state of each of the materials we consider critical to the outcome of a particular print job?

A LIMITED INVESTIGATION

With this in mind SPTF began an investigation into Charge Transfer Sensing to determine if it would be possible to use this technology to measure six different common screen printing variables:

- Degree of Stencil Cure
- Moisture Content of the Stencil
- Moisture Content of the Substrate
- Degree of UV Cure
- Off-Contact Distance
- Mesh Count or Ratio of Solid to Open Area

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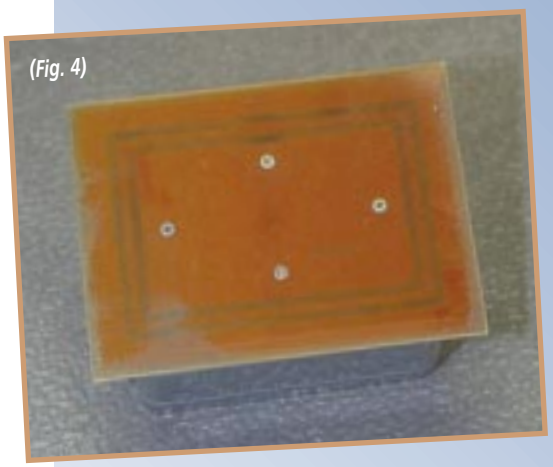
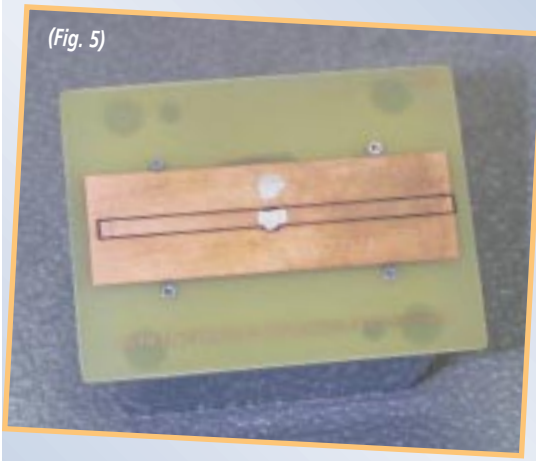
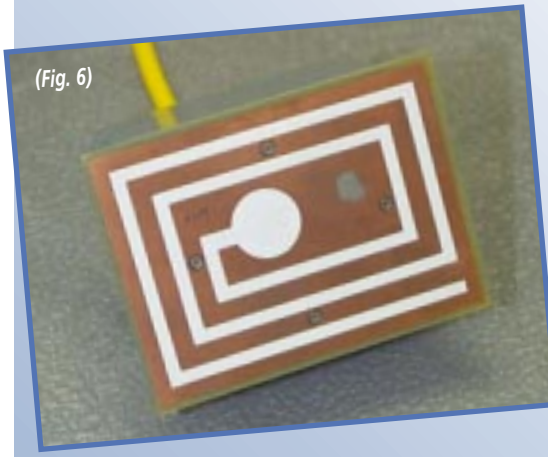


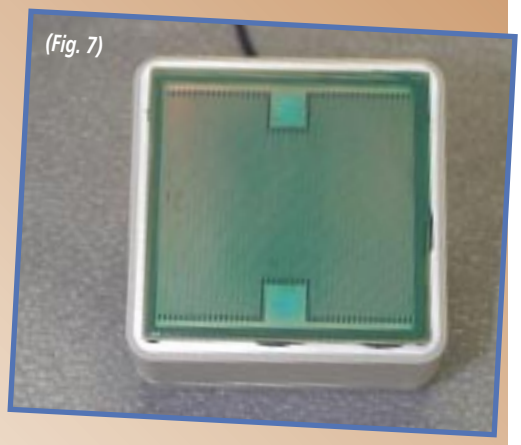
BOX PATTERN PROBE
(FIRST GENERATION STENCIL MEASUREMENT)
- *Circuit Board Design*
- *Larger Sampling Area*
- *Sealed & Off set Probe Surface*



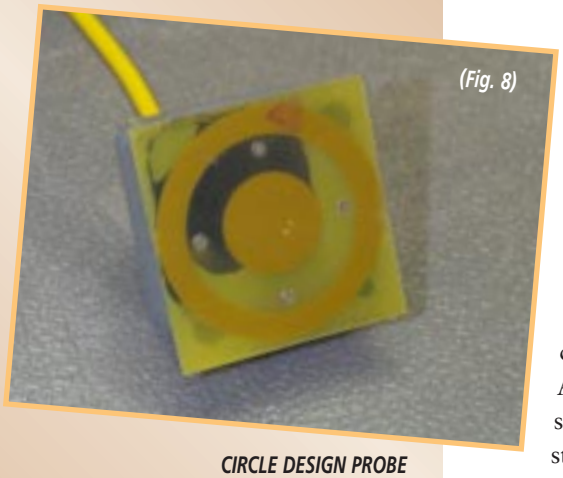
RECTANGULAR GROUND PLANE
(SECOND GENERATION STENCIL MEASUREMENT)
- *Ground Plane Flush with Screen*
- *Expansive Surface Area for Sampling*



SQUARE MAZE PROBE
(THIRD GENERATION STENCIL MEASUREMENT)
- *Increased Line Length for Improved Resolution*
- *Bigger Difference Between Wet/Dry Screen*
- *10X the Sensitivity with Circuit Board Design*



INTERDIGITATED PLANER DESIGN
(OPTIMIZED FOR MULTIPLE MEASUREMENT TASKS)
• 100X the Sensitivity of Previous Probe Designs • Concentrated Field Penetration • Encapsulated and Shielded Circuit • Flat Surface Contact with Screen • Possible applications include: UV Cure, Stencil Cure, Stencil Moisture, Substrate Moisture and Mesh Count



CIRCLE DESIGN PROBE
(FIRST GENERATION OFF-CONTACT MEASUREMENT)
• Circuit Board Design • Extended Range • "Doughnut" Shaped Electromagnetic Field

DOUBLE SQUARE DESIGN
(OPTIMIZED OFF-CONTACT MEASUREMENT)
• Good Results with Low Cost • Works on Any Platen Material, (Does Not Require a Metal Surface) • Could Be Made Self Contained

PROBE DESIGNS

For example the "Paddle Probe" (Figure 2) is very versatile as far as the positioning of the parallel plates around the measurement material is concerned. Still, since paddle spacing is critical the ability to resolve anything but the larger changes in materials is missing with this approach.

Although the "Wood and Copper" probe (Figure 3) looks like it was made for my daughter's 9th grade science project, it's actually quite an improvement from the free floating paddle approach. It does provide rigid spacing for the two copper plates (serving as electrodes) on the surface of the wooden block.

The draw backs are its relatively limited application, difficult construction and a tendency to absorb moisture (requiring frequent recalibration).

An improvement in the ability to measure stencil cure and moisture was experienced by going to a more rigid circuit board design (Figure 4). Also by increasing the physical size of the plates more of the stencil could be measured ensuring a better statistical sample of the surface. This was also our first attempt at sealing the probe from the often hostile environment encountered by screen printing. Although good, this design was quickly replaced by a "Rectangular Ground Plane" (Figure 5) with an expansive surface area crafted to rest flush with the screen surface for even better accuracy. Never being satisfied with the latest result a final solution for the measurement of stencil cure and moisture came in the form of the "Square Maze Probe" (Figure 6). With its increased line length for improved resolution and a new circuit board with ten times the sensitivity this prototype was able to repeatably detect extremely small changes in either wetness or the degree of cure in our controlled stencil tests.

MULTI-PURPOSE PROBE

Having proven the concept of using this technology to measure two different aspects of the stencil we expanded the capability of the instrument by using a more sophisticated approach known as the "Inter-Digitated Planer Design" (Figure 7). Due to its highly concentrated full density field produced through inter-locking digitated electrodes, this probe has proven to be ideal for a variety of measurement tasks. In addition to stencil cure and moisture content, it also measures UV ink cure, substrate moisture and has a good possibility of being usable for mesh count evaluation (SPTF has only performed a limited investigation into mesh count measurement, but initial results look promising).

OFF-CONTACT DISTANCE PROBE

Due to the ability to control the size of the field being generated by the arrangement of the electrodes, it makes it possible to use the relatively low dielectric constant of air to detect certain objects entering the field from outside. The object approaching from outside the field will always have a much higher dielectric constant than free space, thus causing an increased charge on the detector. By careful recalibration and a new "Circle Probe Design" (Figure 8) our instrument now has the ability to sense how far away it is from another object (that object can be metal or non metal, it doesn't matter). Enter another function (off-contact distance) for the "do everything gauge." As in the previous examples the first attempt was not our best effort. The second generation "Double Square Design" (Figure 9) proved to function well for this application with repeatability approaching plus or

minus one thousandth of an inch. That is more than adequate for most screen printing applications.

Why another off-contact probe? A better question is why not, since it's almost no extra effort to build it in with the rest of the functions. Consider two additional advantages of this technology when it's used for off-contact measurement. Metal backing is not required for detecting the platen — it will detect anything. And finally it is very low cost to build, making it very affordable for small printers. This could be another "digital watch" for those who are willing to extend the development effort required to produce the finished product.

CONCLUSION

SPTF has successfully identified numerous technologies with potential benefit to the screen printing industry. In many cases we have completed the development work necessary to prove conceptually that the applications will work. Although our mission is not "new product development," it is about giving the industry the kind of technical information it needs to succeed — information about how the process works and how to measure and control the variables. That goal can not be realized through our efforts alone. It will take the combined efforts of industry leaders, manufacturers and printers to fully realize the benefit of the research being produced here. If you are a manufacturer, please take advantage of this essentially free development work from SPTF to give yourself a big head start in manufacturing one or more of these devices. If you are a printer, call your manufacturer and respectfully ask them why they have not taken advantage of the information being produced at SPTF. Finally if you are one of our industry leaders, let's work together to first set and then become that standard of excellence that others will want to follow.

SOURCES:

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[2]*Dr. Edwards Deming 1900 to 1993*
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412-391-7367 Fax: 412-391-7307

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