

# Printed Circuit Boards— An Easier Way

If you've wondered how some people can make nice-looking etched circuit boards, this article will be a revelation. Even beginners can come up with professional-looking boards.

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**H**ow did you wire your first ham radio project? Old-timers may recall driving finishing nails into a pine board and then wiring point-to-point with components and bell wire. This method

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was called "bread board." Now that the good old days have all but faded from memory, we're faced with the more difficult task of printed circuit board fabrication for our construction projects. Nails and bell wire have given way to copper-clad boards, photo-sensitive

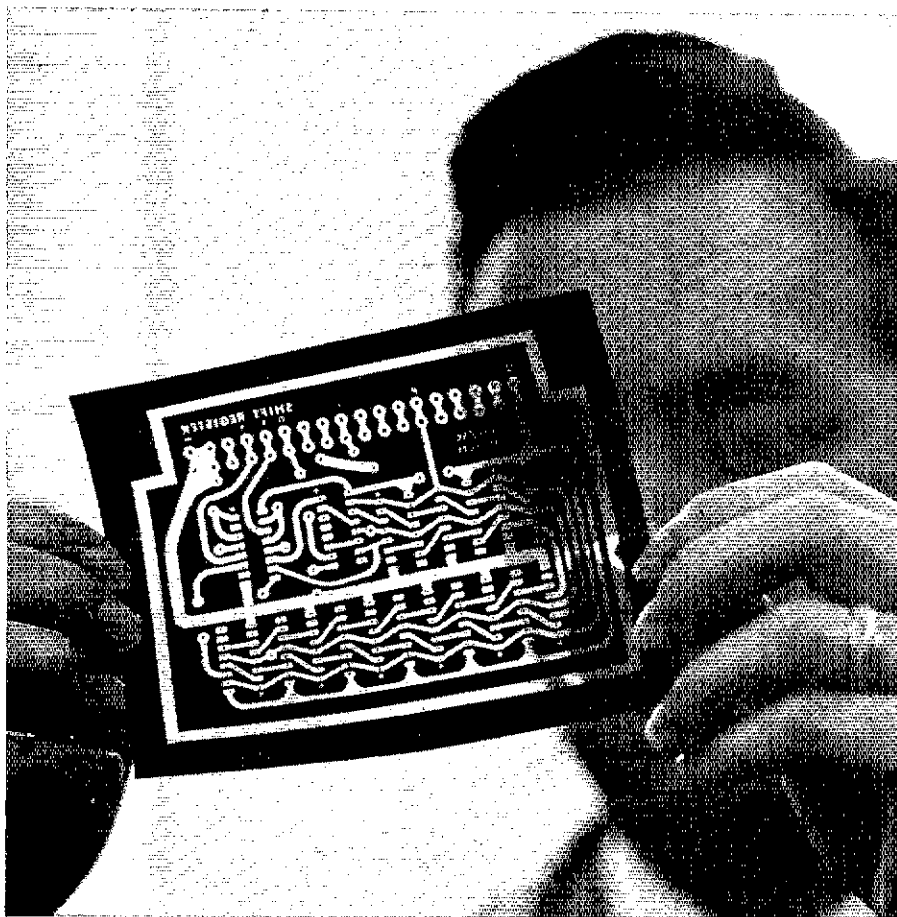
coatings and etching solutions. Anyone who has made a board from scratch will admit it can be a messy job.

I recently experimented with a new approach which is made possible through the development of a new product called Image 'N Transfer or I.N.T. film.<sup>1</sup> This new technique eliminates much of the hassle and makes it possible to produce professional-looking boards.

Attendees at the 1976 ARRL convention in Denver saw the I.N.T. process demonstrated by Bob Shriner, WA0UZO. Bob used the sun as an exposure source. The result was a good-looking circuit board made with a minimum of effort.

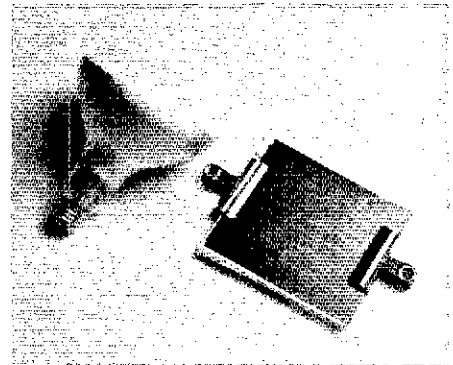
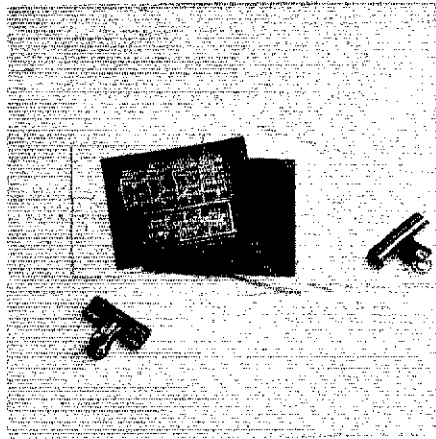
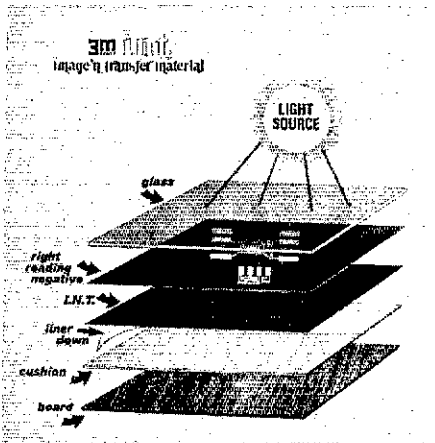
The I.N.T. material consists of a polyester film which has been coated with an ultraviolet sensitive coating. This material may be exposed with a no. 2 photoflood or as WA0UZO did, with direct sunlight. The film is developed with a special solution, and the resulting positive is a reversal of the image exposed on the I.N.T. sheets. These sheets may be handled in subdued indoor light without danger of exposure. A clear peel-off liner covers the back of each sheet to protect the emulsion until development.

I.N.T. is ideal for circuit-board construction because once the film is exposed and developed, the image can be rubbed off or transferred to the circuit-board material by burnishing. This is similar to the manner in which rub-on letters are transferred to a poster or sheet of paper. When an I.N.T. image is



The graphic-arts film negative ready for exposure to Image 'N Transfer material.

<sup>1</sup> Manufactured by 3M Company, P. O. Box 33600, St. Paul, MN 55133.



The image on the negative is transferred to the Image 'N' Transfer (I.N.T.) where it appears in positive form. This transfer is accomplished by making a contact printing frame using glass, the negative, a sheet of I.N.T. and a sheet of thin sponge or tissue for a cushion.

The contact frame should be clamped tightly. Since the I.N.T. is sensitive to ultraviolet light, exposure can be made to direct sunlight, or to a lamp such as a number 2 photoflood. It may be a good idea to experiment with a test strip to find the right exposure time for your light source.

transferred to a plain copper-clad board, it forms a resist that easily withstands the ferric-chloride etchant.

### The Sequence

Here's how I experimented with I.N.T. The May 1976 issue of *QST* featured a construction article on learning to work with ICs by Jerry Hall, K1PLP and Charles Waits, WA6GVC. The article included a suggested circuit-board layout for a frequency counter, printed to scale for use by interested hams. I removed the page, took it to a local offset printer, and had him shoot a same-size lithograph-quality negative. Since I was willing to pay cash and eliminate paperwork the cost was \$2.50. A check of other suppliers in the St. Paul/Minneapolis area indicates a range of cost from \$2 to \$5 for a good-quality negative. You may have to shop around for a supplier who will bother with noncommercial work, but the cost generally isn't steep.

The next step was to make an exposure frame. I used a piece of glass for the base, placed some thick industrial-grade cleaning tissue over it for cushioning (a thin sponge would work as well), and laid the I.N.T. material over it (liner side down). The litho negative went down next, and then a second piece of glass was used to press everything together. Two paper clips hold the assembly together.

I exposed the film, using a no. 2 photoflood lamp and an exposure time of about a minute and a half. You might want to experiment with narrow test strips of I.N.T. to arrive at the optimum exposure time for your light source. Timing is approximate and not critical. The main precaution is to avoid over-exposure since it tends to harden the image and make it difficult to transfer.

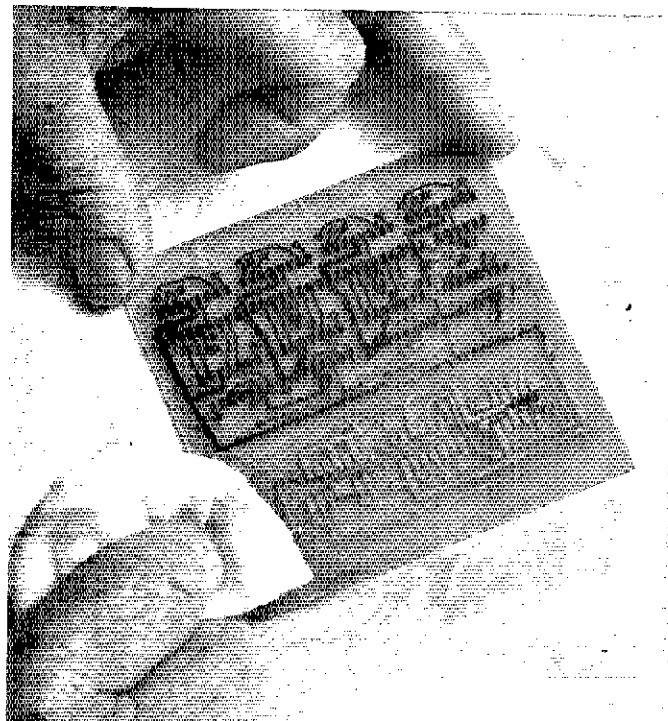
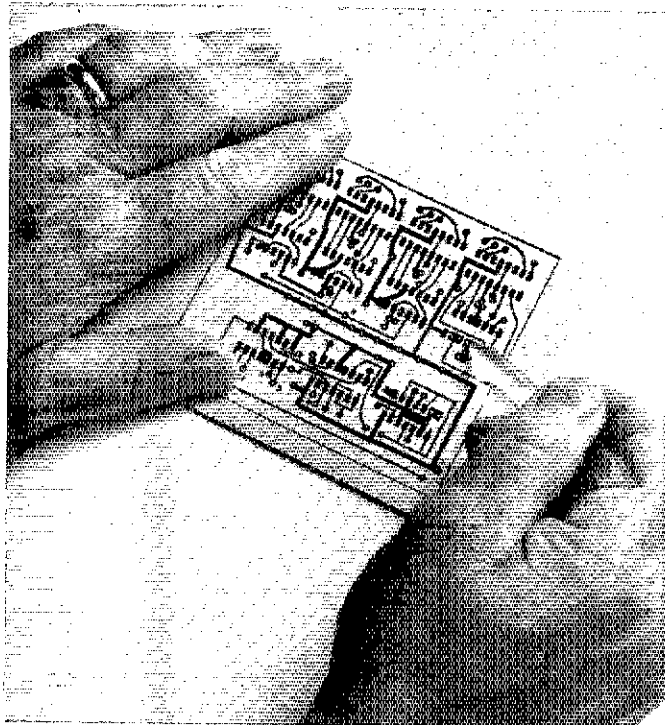
After exposing, I disassembled the frame, removed the I.N.T. and peeled



The I.N.T. image is developed on a piece of glass using the 3M brand I.N.T. processing solution and a cotton wipe. A newspaper or tray may be used to collect excess developer. Developed positives should be kept out of strong light to avoid further hardening of the image.

off the protective film from the emulsion side. Following the manufacturer's directions, I poured approximately a tablespoon of developing solution on the center of the I.N.T. and spread it evenly with another piece of industrial wiping tissue. The water-based developer is nontoxic and the amount used is not important. After 15 or 20 seconds of wiping in a circular motion,

the black emulsion was removed from areas not hardened by the light, and I had an image of the frequency-counter circuit board. A rinse in the sink removed the chemical residue. To speed the drying process, I used a soft rubber squeegee to remove the excess water from the base side of the I.N.T. Since I.N.T. is polyester and is nonhygroscopic (unlike conventional photo-



The I.N.T. image is then transferred to the copper-clad board by burnishing with a blunt tool. The pattern serves as an etch resist. Careful inspection is important to make sure that no areas are missed and the pattern is firmly adhered in all areas. Once the I.N.T. pattern is in place, the board is etched using standard circuit board techniques. Then the I.N.T. pattern is removed with isopropyl alcohol, and the board is ready for drilling.

graphic film), it doesn't absorb water and dries quickly (allow five minutes before transferring). At this point the circuit image was ready for transfer to the board.

Before starting, I cleaned the copper surface thoroughly with isopropyl alcohol to remove any contaminants that could interfere with the transfer step. If you have used rub-on letters, you no doubt know how important it is to burnish hard enough for good transfer, and yet not so hard as to stretch the backing paper and split the letters. The I.N.T. backing is somewhat more stable dimensionally than transfer-letter sheets, so the stretching problem is minimal. Still the burnishing process requires some care to ensure a good job, especially on a complex circuit pattern with many lines. Registration can be best handled by taping one I.N.T. edge and burnishing away from the tape side — thus preventing most movement of the material.

After transfer of the pattern to the board, I made a careful inspection under bright light to make sure that all the details were in place. A permanent-ink marking pen may be used to make any corrections since the ink is also a good etch resist. The manufacturer suggests that the green liner sheet which comes with each piece of I.N.T. be used for a second burnish to make sure that all of the pattern is tightly affixed to the board.

Once the circuit image was in place the board was ready for etching. Here I

proceeded just the same as with any circuit-board process and made sure that the etchant temperature was correct and that the tray was properly agitated. If tongs are used to lift or inspect the board during this step, be sure not to grip over the I.N.T. pattern, as it can be scratched, causing the etchant to remove that portion of the circuit pattern.

As the photo shows, the finished board is sharp in detail and neat looking. The I.N.T. transfer material is removed after etching by using the same type of alcohol used to clean the board before burnishing.

#### So What Else Is New?

As you may have guessed, 3M's Image 'N Transfer material wasn't developed for ham radio circuit-board makers alone. It is a part of 3M's Industrial Graphics product line which includes Color-Key materials and other items for artists and printers. It just happens to be a good resist material.

You can also use the I.N.T. process to make customized rub-on panel decals or chassis labels to dress up your construction projects. Anything that can be converted to negative form can be put on I.N.T. and transferred to a hard surface. When I.N.T. is used for labeling, the finished product should be sprayed with a protective lacquer to make sure that it isn't scratched off or smeared by solvents (experiment with lacquers on scrap I.N.T. to determine best compatibility).

There is another means available to amateurs interested in making their own circuit boards without using a litho negative; 3M's Color-Key material, which is processed in a manner similar to I.N.T., may be exposed to a transparent or translucent copy of a board layout to form a negative. The negative is then used to image the I.N.T. for conversion to positive rub-on form.

Note that a transparent or translucent master circuit-board layout is required, since the light must pass through the material to expose the Color-Key. When using this technique, you may want to prepare your original layout on vellum or on an absorbent paper which can then be treated with vegetable oil to make it translucent. Or, you can purchase transparentizer solutions in aerosol form from art and design stores.

#### Where Do I Buy I.N.T.?

Radio clubs or other groups interested in a large quantity can save money by purchasing I.N.T. in commercial lots (ten 8-1/2 × 11-inch sheets minimum order) from graphic-art, engineering and printing products dealers. The packages are approximately \$30 and developer is \$3.45 per quart.

There are plans by several suppliers to repack I.N.T. in single lots for sale to amateurs or for prototype circuit production. Contact Glen C. Whitehouse, 11 Newbury Drive, Amherst, NH 03031 or Robert Shriner, P. O. Box 969, Pueblo, CO 81002.