TECHNICAL PAPER

The History of Insulation Displacement Technology

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Abstract
The need to physically connect pieces of metal together has been around for thousands of years. In the modern era of electronics, the physical connection requirement is compounded by the need for a low resistance electrical path. In both cases, the process of soldering has proven to be an excellent and time tested solution, with evidence dating back to 4,000 BC. Soldering two metal components together means that the joint is heated and a filler metal with a lower melting point than the constituent pieces is deposited to complete the connection.

THE HISTORY OF INSULATION DISPLACEMENT TECHNOLOGY

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Around the time of World War II, a new technique for joining metals was formalized termed "cold welding." The principle is conceptually quite simple: in a vacuum, two pieces of similar metals will simply join when placed in close proximity. Assuming a clean surface and no oxidation or corrosion, the two metal pieces effectively lose any boundary condition to define where one ends and the other begins. It was then discovered that this same phenomenon could be observed in open air if the gases between the two pieces of metal were completely forced out using extremely high pressure. One of the first applications for this new kind of metal joinery was known as wire wrapping. Using a post with sharp corners, such as a rectangle, a wire could be wrapped around it under tension. At each of the four corners of the post, the compressive forces are so high (approaching 15,000 psi) that a cold weld is formed. A cross-section is shown in figure 1 where the corners of the post can be seen forced into the wrapped wire.

For every wrap of wire, four cold welds are formed. As such, using multiple wraps results in an extremely strong, low resistance connection that also eliminates many of the reliability issues found in soldered joints. Wire wrapping quickly became the de-facto standard for connecting circuit boards, implementing telephone switchboards, and electronics prototyping. In 1959, the cold weld concept was applied to a new invention called the "insulation displacement contact" or IDC. Developed by Edward Leach and Evert Levin from Minnesota Mining and Manufacturing, it was described as a "solderless connector for insulated small wires." Their proposed process "penetrated or cut the insulation…to make a positive metal-to-metal juncture" using a forked slot that is designed to displace the insulation as shown below.

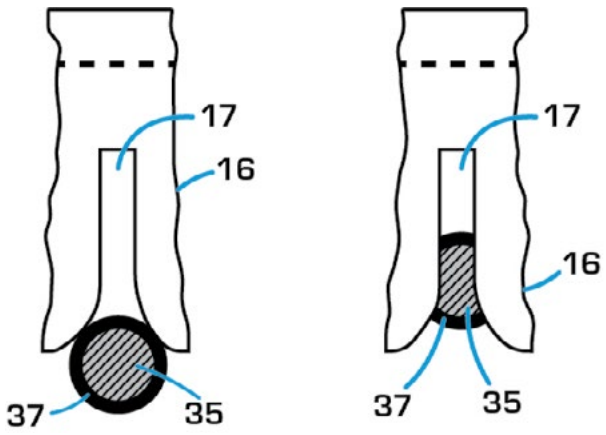

Figure 1
Patent drawing of an insulation displacement contact [US Patent #3,012,219]

The fork is designed to function as a knife that cuts into and then displaces the insulation. It then acts as a strong spring, which squeezes the metal wire with enough force to cold weld it with the fork and create a gas-tight connection. This is a highly reliable joint as long as the connector and the wire are properly matched and there is a mechanical strain-relief to limit external forces on the wire.

One of the first industries to widely adopt IDC connections was telecom, particularly for telephone systems. A “punchdown block” contained rows of IDC blades that allowed the installer to quickly make highly configurable and reliable connections. The first iteration of this connector was referred to as the “66 block” and was optimized for analog voice signals to replace older screw terminals. This was supplanted by the newer style “110 block” and is shown below. Even today, it is regularly used for high-speed Category 5 cable in ethernet installations.

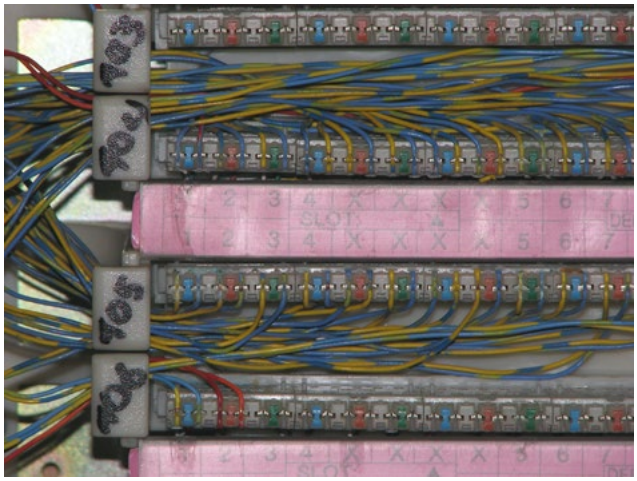

Figure 2
IDC 110 punch block for ethernet installations
[Wikipedia]

As IDC connections became more prevalent and their track record of reliability strengthened, the rise of the computer age created an entirely new demand for quickly terminating and connecting ribbon cables. Once ribbon cable spacings and form factors were standardized, IDC connectors became the de facto standard for mainframe interconnect, tape drives, printers, and a variety of consumer electronic components. An example IDC ribbon connector is shown below. To create the connection, the cable is simply inserted and the plastic housing is pressed shut.

Figure 3
IDC Ribbon Connector
[Digikey]

Currently, IDC still serves as one of the most ubiquitous and reliable connection methods on the market. With a long track record in a variety of industries, IDC contacts have now started to take the lead in the transportation sector as well, due to their low cost and environmental robustness. The newest IDC technologies are geared toward automotive manufacturers and include such advancements as low profile connectors and press-fit pin connectors. The latter is particularly interesting as it combines two cold weld junctions in a single pin. As seen in the following figure, the wire itself is cold welded to the contact using a traditional wedge-shaped blade, and the contact is cold welded to the PCB as it is press-fitted into a plated board hole.

Figure 4
Combination press-fit pin and IDC wire-to-board connector [AVX]

IDC connectors are also fit for various industrial applications due to their reliability and ease and speed of installation, offering installation speeds up to 50 times faster than alternative wire-to-board connections (see Figure 5 below). Additionally, with IDC connectors, the terminated wire and connector can be potted for wet environments, making them suitable for industrial operating conditions.

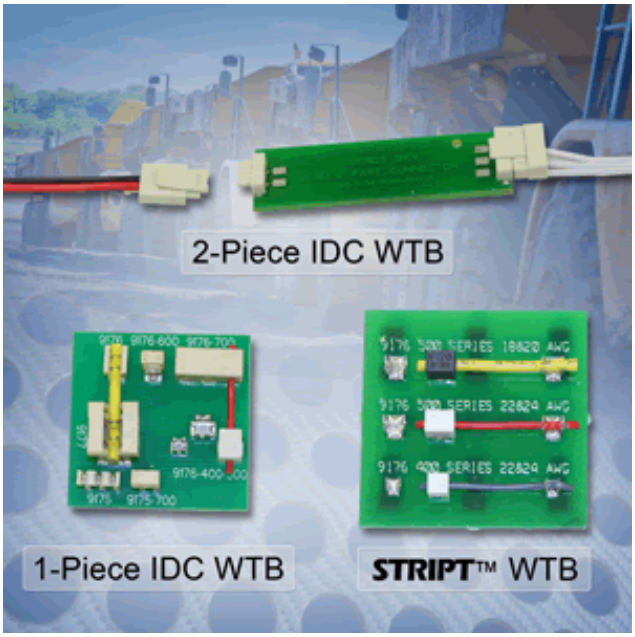

Figure 5
An image highlighting the use of IDC in industrial applications [AVX]

The invention of IDC-type connectors based on cold-welded contacts recently celebrated its 60th anniversary. Due to its simplicity and reliability, this technology has been adopted in nearly every electronic application one can think of. As computer and high-speed data systems become ubiquitous, there is every reason to believe that IDC connectors will continue to serve electronic designers for decades to come. To learn more about the latest IDC technology, visit the AVX website.

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