Since the 1950's, the electrical industry has been using vacuum contacts for high voltage circuit load interruption. These vacuum contacts have the capability of interrupting high voltage power with the contacts moving only 1/4" or 3/8". This has allowed small low-power mechanisms to replace the previous large mechanisms with heavy springs and large operating power requirements. Vacuum contacts have this capability because a vacuum is an excellent insulator. Electrical current cannot flow across a gap between two conductors unless there is a conductive path. Two contacts that are butting and carrying current can be parted in a vacuum (which has no conductive path) and the current will stop. In a practical case, it is found that contacts parting only 1/4" will reliably interrupt load in circuits over 15,000 volts, while maintaining an open gap BIL of 95 kV. Contacts parting 3/8" will reliably interrupt load in circuits over 35,000 volts while maintaining an open gap BIL of 150 kV. Reliable interruption will occur for capacitive or low-power factor inductive circuits, including any type of load power factor in-between.

Contacts parting only 1/4" will interrupt load in circuits over 15,000 volts.

Contacts parting only 3/8" will interrupt load in circuits over 35,000 volts.

Vacuum Switching

Vacuum contacts were developed during the 1940's. They were developed for use in switching radar circuits.

Tungsten was the material used for making contacts in the beginning. It was the only metal that could be made clean enough so that it would not out-gas in high vacuum environments. The material is very hard, and when the two contacts are separated by a very small gap, electron flow will quickly stop. Since there are no gas molecules in a vacuum available for ionization, electron current cannot move across the open gap.

When these contacts were tested for use in the power industry, it was found that large currents could be interrupted with high voltage potentials across the open contacts.

Unfortunately the switches were too good. When the contacts were opened, currents were forced to zero in microseconds. This was a problem with inductive distribution circuits. Due to the inductance the current would try to continue flowing causing a rapid increase in voltage, called "inductive kick." This high voltage flashed across insulators causing damage.

Another problem with the available technology was the need to maintain high vacuum levels. Materials available were not gas free and when used in a vacuum bottle the gas tended to migrate out lowering the vacuum level.

Test equipment available did not allow checking vacuum level after the contact "bottle" was sealed. Ability to test vacuum is important to determine if the vacuum level is degrading with time.

Technology Advancements

During the 1960's many advancements were made in vacuum technology. Research in space exploration contributed to development of materials more suitable for use in high vacuum devices. These cleaner gas free materials made it possible to develop tungsten copper alloys more suitable for load switching without causing transient voltage spikes.

To be able to measure vacuum life, a technique was developed to measure vacuum levels. To measure the vacuum level the vacuum contact "bottle" was used. By applying a D.C. voltage across the open contact and applying a magnetic field, ion current could be measured. By tracking the change in ion levels with time, vacuum integrity could be measured.

The contact "bottle" was changed from glass to a special aluminum oxide ceramic that was much harder and could be processed at much higher temperatures. Processing at very high temperatures in a vacuum chamber cleaned the internal surfaces, and completed the brazing process giving a clean sealed vacuum "bottle" with no vacuum leakage.

The tungsten contacts are now replaced with a tungsten-copper alloy. The contacts are made of tungsten powder held together by a copper bonding produced in a vacuum furnace. The new contacts do not "outgas" and they have the very desirable characteristic of not forcing current to zero. This is because as the contacts part, carrying current, the current starts an arc which melts a microscopic puddle of copper on the negative electrode or "cathode". This molten copper provides the ions necessary to carry the full current across the gap with its normal sinusoidal waveform. As the current passes through a natural zero, the polarity changes and the opposite electrode becomes the

Trayer
Trayer Engineering Corporation
898 Pennsylvania Avenue • San Francisco • California • 94107
(415)285-7770 • (800)377-1774 • Fax (415)285-0883 • sales@trayer.com • www.trayer.com

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