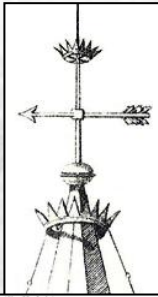


ArresterWorks



(No Model.)
A. WURTS & O. H. BALDWIN.
 LIGHTNING ARRESTER.
 No. 433,430. Patented July 29, 1890.

First Gap
 Solenoid Coil in series with gap 1
 Inductor in series with gap 1

E. G. P. OELSCHLAGER & K. O. P. SCHROTTKE.
 LIGHTNING ARRESTER.
 No. 566,011. Patented Aug. 18, 1896.

Sept. 22, 1942. **H. W. KALB.** 2,296,708
 CERAMIC INTERRUPTER DEVICE
 Original Filed April 21, 1939

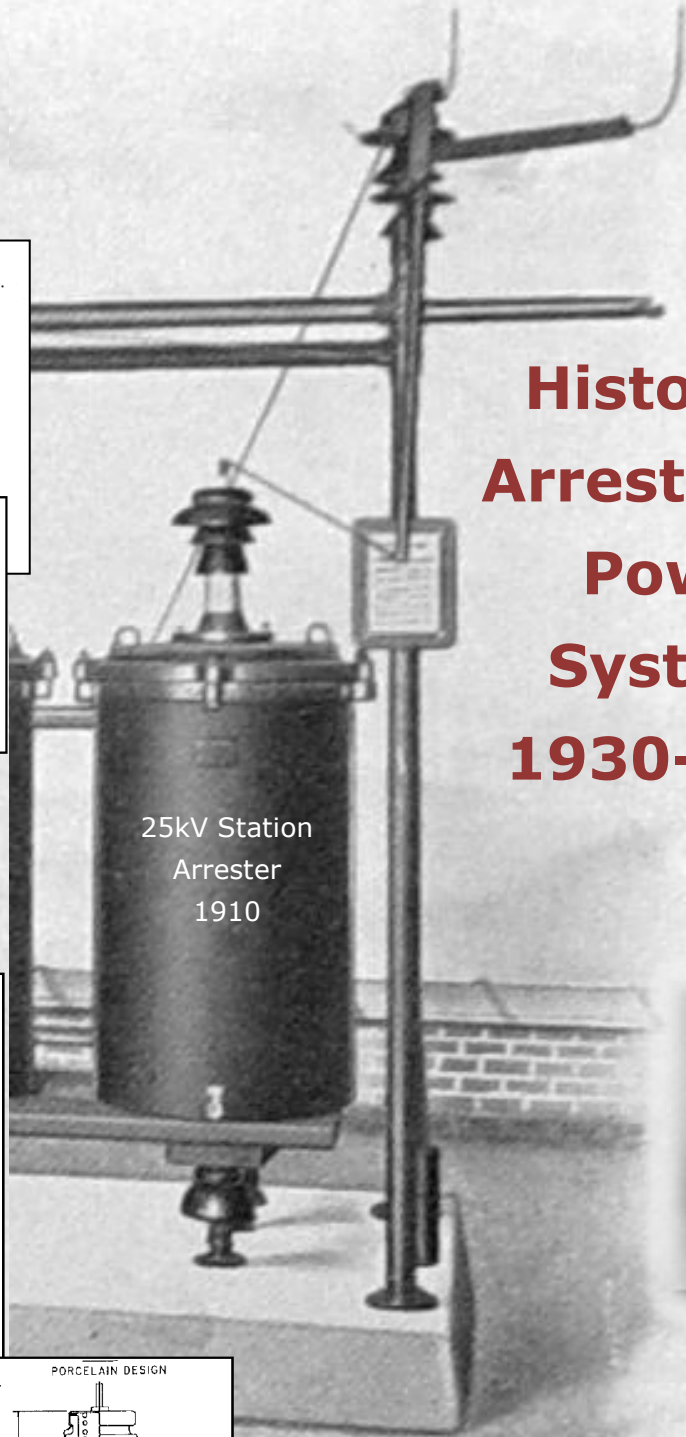
Jan. 30, 1962 **J. W. KALB** 3,019,367
 LIGHTNING ARRESTER AND GAP UNIT STRUCTURE
 Filed Dec. 4, 1957

FIGURE 1

FIG 1a POLYMER DESIGN

FIG 1b PORCELAIN DESIGN

PHYSICAL COMPARISON OF 8.4 KV MCOV POLYMER AND PORCELAIN ENCLOSED DISTRIBUTION CLASS ARRESTERS



25kV Station Arrester 1910



25kV Station Arrester 2010

History of Arresters on Power Systems 1930-1965

By Jonathan J Woodworth

1930 - 1965

By Jonathan Woodworth ArresterWorks

This part of the History of Surge Protection in Power Systems takes us through the Silicon Carbide Arrester Era to the beginning of the Metal Oxide Varistor Era. The Expulsion type arrester was developed during this time period and in some cases outperformed the SiC arrester.

We also see during this time period the continued dominance of the GE and Westinghouse arrester design teams as well as the beginning of the end for these long time rivals and giants. Other changes include the following: Ohio Brass, Line Material, and Joslyn Manufacturing emerge as formidable suppliers of arresters; the ESSCO Company from Philadelphia disappears; standards for arresters are first published and go through significant changes as the arrester designs continue to evolve.

A New Expulsion Arrester

In early 1932, an innovative engineer at Westinghouse Electric Company, Walter G. Roman, was working on a completely new concept in overvoltage protection. His design would re-invent the expulsion arrester and begin the era of the over current protective device known as the cut-out. Roman introduced to the lightning protection world the first expulsion arrester that used ablative action to extinguish the follow current arc. As stated in Part 2 of this series, the first expulsion arresters were patented in 1918 utilizing a rapid heating resistor to produce heated air to blow out the arc. Roman discovered and developed material that

produced large quantities of de-ionized water vapor that evolved in the presence of an arc. When channeled in the proper direction, the vapor would extinguish the arc when the system voltage crossed zero.

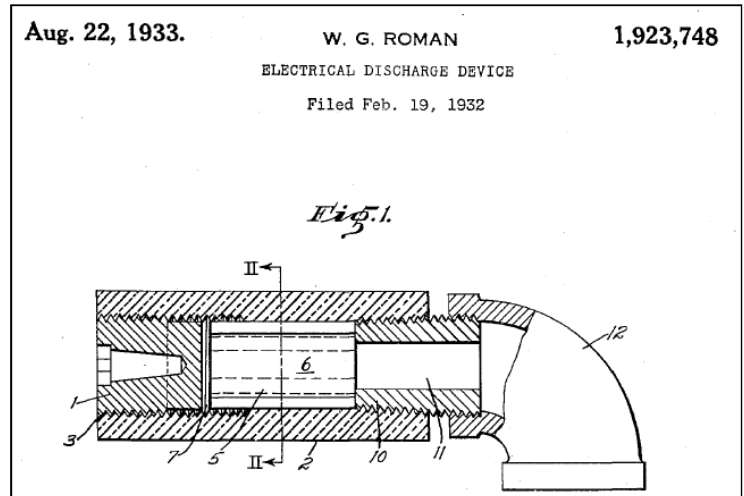


Figure 1 Electrical Discharge Device using rapid vaporization of material to create de-ionized water to extinguish the arc. The basis of the New Expulsion Arrester and the over-current device known today as the fuse cutout.

My invention relates to an electrical discharge device and particularly to an arc discharge device having a self-interrupting characteristic.

In the distribution and utilization of electrical current, particularly at high voltages, it is customary to protect distribution lines and apparatus connected thereto with various kinds of over-voltage discharge devices. Of the various devices which have heretofore been used, the simple arc gap is most efficient for initiating and discharging the over-voltage. However, after break-down, the simple gap has many undesirable characteristics, the chief among which is that it permits the dynamic voltage of the line to maintain the arc; and consequently dynamic current is discharged by the device.

Figure 2 Eloquent verbiage describing ablative material and how it benefits arresters

Of course this device still required a series gap, but since it was necessary for this device to be open to the atmosphere to operate, all the materials used were designed to be water insensitive, which has made it a very long lasting product. Although this arrester type has not been produced for decades, a short drive through the US countryside will show that thousands, if not millions, are still in use on transformers dating back to the 40's and 50's. Figure 2 is an eloquent first paragraph of Roman's 1933 patent on this device. Figures 3 and 4 both show recent photos of this type of arrester still in use. They are both members of the "Half Century Sentry Club".



Figure 4 Another "Half Century Sentry".
1950 Hi-Stroke Rural Arrester by
GE Still in service Oct 2011

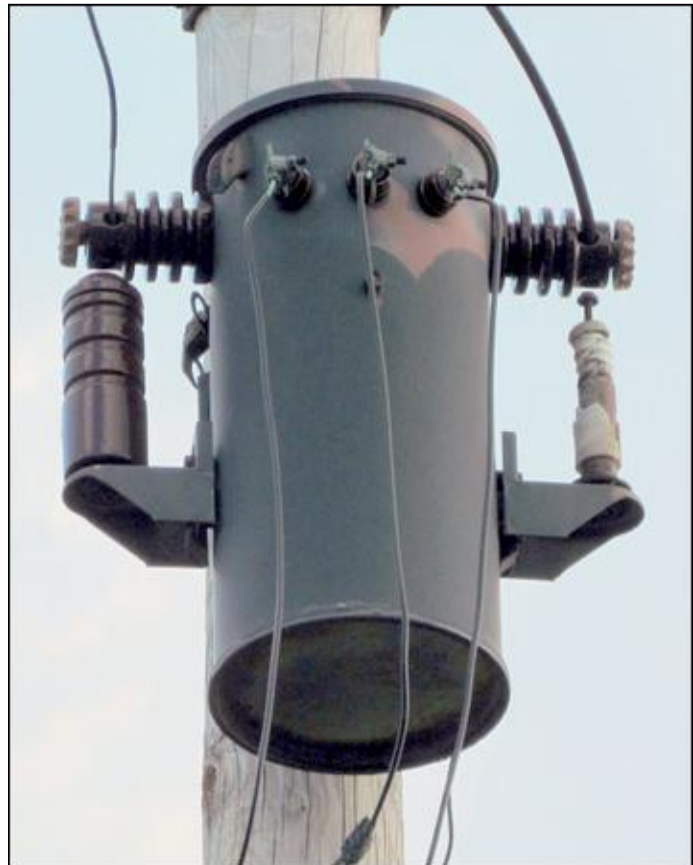


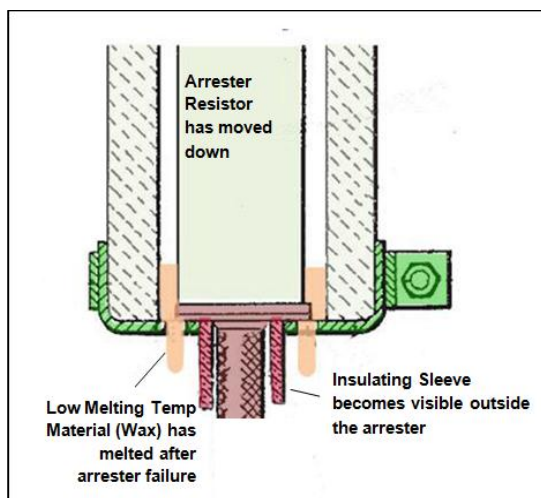
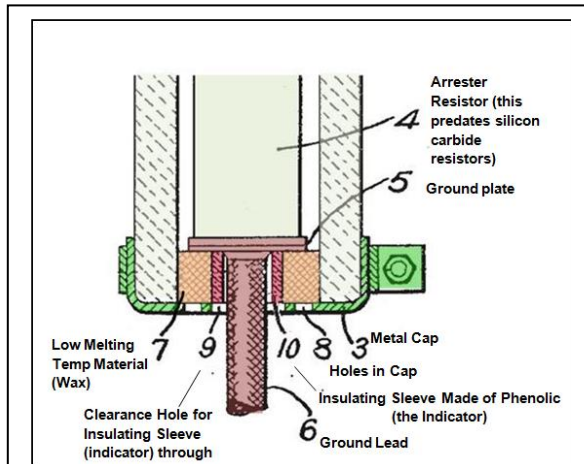
Figure 5 "Half a Century Sentry" Circa 1945 Expulsion
Arrester with housing blown off on right side arrester and
fully intact left side arrester. (GE) Still in Service Oct 2011



Figure 3a Early Expulsion
Arrester by Joslyn Supply Co.
1940 Vintage

Ground Lead Disconnecter and Failure Indicator

On May 10th, 1922 Lawrence Rice Golladay filed for a patent for an arrester indicator (note: it was not called an interrupter or disconnecter because it was not meant to be either). Obviously the inability to visually determine if an arrester had failed or not when installed had become an issue even at that time.



Theory of Operation

When the arrester fails, the resistor (4) heats the wax (7). The heated wax melts and flows out of the arrester cap (3) through holes (8) and the indicator (10) is pushed through hole (9). At the top of the resistor (not seen in colored views, a larger gap is created that then improves the voltage withstand of the arrester.

Figure 6 Earliest Failed Arrester Indicator by Galloway (Westinghouse) Application in 1922

In patent 1,642,239, Golladay introduced the concept of using the arrester resistor to melt a low temperature material allowing an insulating sleeve to protrude out of the bottom of the arrester. See Figure 5.

The concept of the arrester ground lead disconnecter as we know it today can be traced back to April 22, 1939, when Ralph H Earle applied for a patent. At that time, Ralph was a fuse and arrester design engineer for the Line Material Company in Milwaukee Wisconsin. Having expertise in both fuses and arresters was an obvious advantage. His concept was patented in 1942. The concept of using an explosive charge to separate the ground lead is still in use today, seventy years after it was first introduced. For it to have survived this long is a testament to the quality and uniqueness of this concept

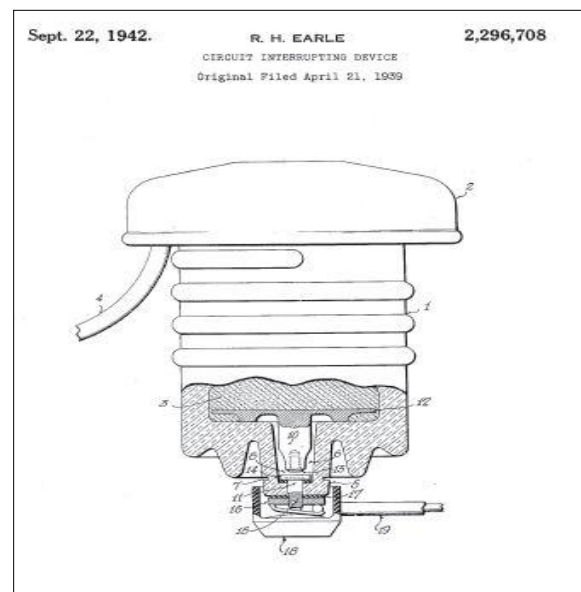


Figure 7 First Patent to include an explosive disconnecter for positive disconnect

Station Class arresters and Current Limiting Gaps

By the 1950's, system voltages were approaching 500kV. Surge arresters for these systems were very large. Silicon Carbide (SiC) arresters with series gaps were the dominating design for this voltage class. The arrester heights were 15 or more feet per 100kV. This made arresters for higher voltages a significant mechanical challenge as well an electrical challenge. Westinghouse ran an ad (as seen in Figure 7) on the back cover of Fortune Magazine in January 1949 promoting their company's prowess in the power industry. Can you imagine an arrester ad on the cover of Fortune Magazine today?

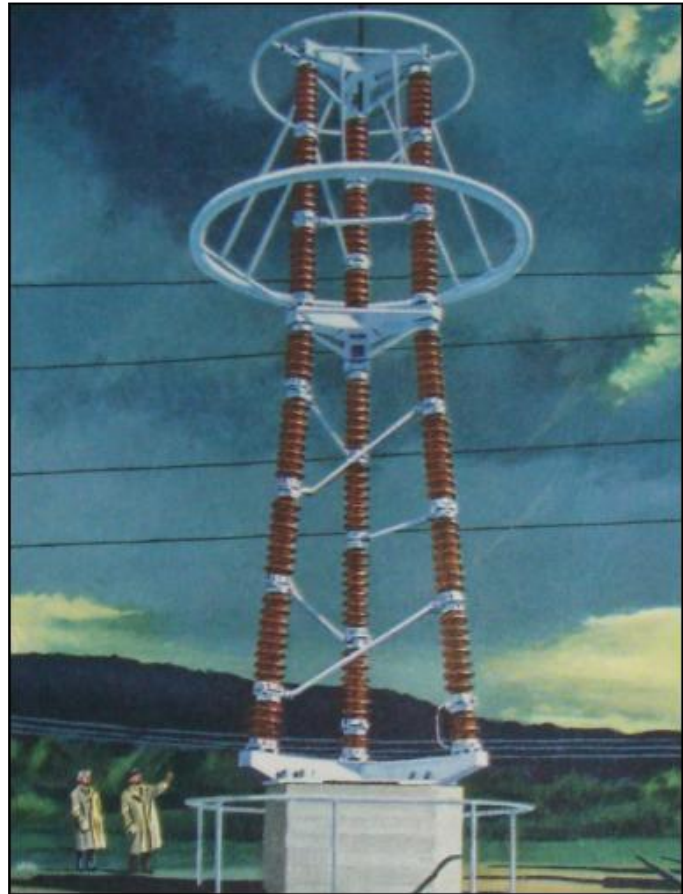


Figure 8 Surge Arrester for 500kV system by Westinghouse Electric Company appearing on the back cover of

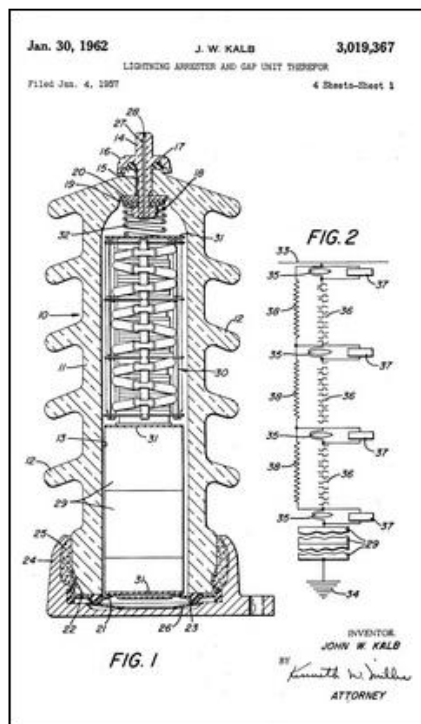


Figure 9 Ohio Brass - Kalb 1962
Current Limiting Gap for
Station Arrester Patent

Again, the engineers of the day came to the rescue. Jack Kalb, an ex-GE engineer with training at ASEA in Sweden, developed the current limiting gap in 1957 while working for the Ohio Brass company. In his patent application, which was filed in 1957 but not granted until 1962, he used the concept of stretching the arc in a chamber that effectively increased the resistance of the arc and assisted the blocks in limiting follow current. This patent was highly successful for Ohio Brass and brought them quickly into the GE-Westinghouse arrester design competition. What Jack Kalb accomplished with the current limiting gap was to reduce the length of the arrester by some 25%. When considering the length arresters were becoming for higher voltages, this was a significant accomplishment.

Silicon Carbide Arrester Technology

Throughout the 1930-1950 time frame, the Silicon Carbide Valve Arrester design dominated the scene. Both the distribution type and the station type arrester used this technology. Many variations of the design were patented but all remained adaptations of the 1926 ESSCO – McFarlin design. These arresters have been largely eradicated from substations and replaced with the more modern MOV type arresters, but on distribution systems that is not the case. Like the expulsion arrester, it doesn't take long to locate a series gapped silicon carbide arrester in service with a ride through the country side. These arresters live on and continue to protect. The last production of this type of arrester in the US took place in 1994 and since then only the next era of arresters has been produced in the US. Figure 8 is an example of a glass housed silicon carbide arrester with the silicon carbide just packed into the glass container. This design was produced by the Line Material Company from 1934 to 1957. Many thousands of these arresters can be seen in service today and since they have glass housings, the internal components can easily be observed and are routinely found to be in perfect condition.

Through the 1960's and 1970's the designs continued to improve both in performance and size.



Figure 10 Glass Housed Silicon Carbide Arrester produced by the Line Material Company from 1934 to 1957.

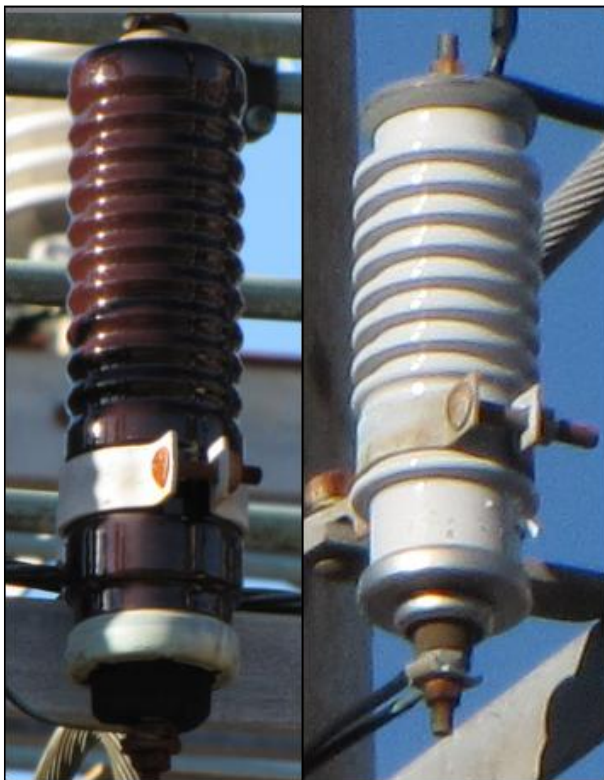


Figure 11 The mid 1960 arrester color conversion from brown to grey was rapid and entirely a marketing and sales scheme to increase sales. It does however make it easier in identifying the age of an arrester quickly

The Sky Blue Grey Conversion

In the mid 1960's, First Lady "Lady Bird" Johnson was able to persuade her husband, President Lyndon Johnson, to steer a bill through the US Congress titled "The Beautification Act of America". As a result of this law, billboards were removed en masse from the US highways and in general the US highways were cleaned up to make traveling through America a more pleasant experience. This gave some clever marketing person a perfect

opportunity to suggest changing insulator, arrester, and transformer colors from dark grey and brown to a beautiful sky blue/grey. There was no technical reason for the change; it was purely a scheme to increase sales by having a more pleasant colored product. Because of the Beautification Act, once one company made the change, it almost became mandatory for all others to follow. The conversion on distribution arresters was quite rapid and within a few years, all arresters in the US were produced using sky blue/grey porcelain.

Arrester Suppliers

At the beginning of this era, General Electric and Westinghouse Electric Companies were clearly the dominating forces in this industry segment. They both had been major contributors to innovative designs in power system arresters from the earliest power systems days. They continued on throughout this era again as dominating forces. However not all companies survived this period of time, the Electric Service Supply Company (ESSCO), who had been a supplier of both communications type lightning arresters and power system lightning protectors, ceased operations somewhere in the late 1940's to mid 1950's. In 1928, the Line Material Company entered the arrester business with an expulsion arrester. Another newcomer, JR Kearney Co, entered the arrester business in the early 1930's and was a dominant force in the arrester-cutout combination as the expulsion type concept became popular. Somewhere during this period, the Joslyn Manufacturing Company joined in on the lightning protection business. In the early 1950's, Jack Kalb and ASEA lead the Ohio Brass company into the lightning protection industry. By the end of this era, the US had six competing companies producing lightning and surge arresters for the industry.

Technology Marches On

By the end of the 1950's, the expulsion arrester technology had matured and no new designs using this type of arrester were reaching the US patent office. By the mid 1970's, the last gapped silicon carbide designs were submitted to the patent office. The next technology to be used in both low and high voltage surge protection had emerged. In the summer of 1967 the future of surge protection was changed forever with the discovery of a solid state material that had all the attributes needed for overvoltage protection. The gapped silicon carbide era had come to an end, yet their service to the power systems continues today with millions of SiC arresters still in service.

In part 4 of this series, the discovery and development of the ZnO arrester, introduction of the polymer housed arrester, and introduction of the elbow arrester, as well as the future of surge protection, will be explored. The changing of the guard in the supply of lightning arresters will also be covered in the next segment. It is hard to imagine that after a century of dominance, the Westinghouse and GE era also comes to an end.

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Comments are welcome jonathan.woodworth@arresterworks.com