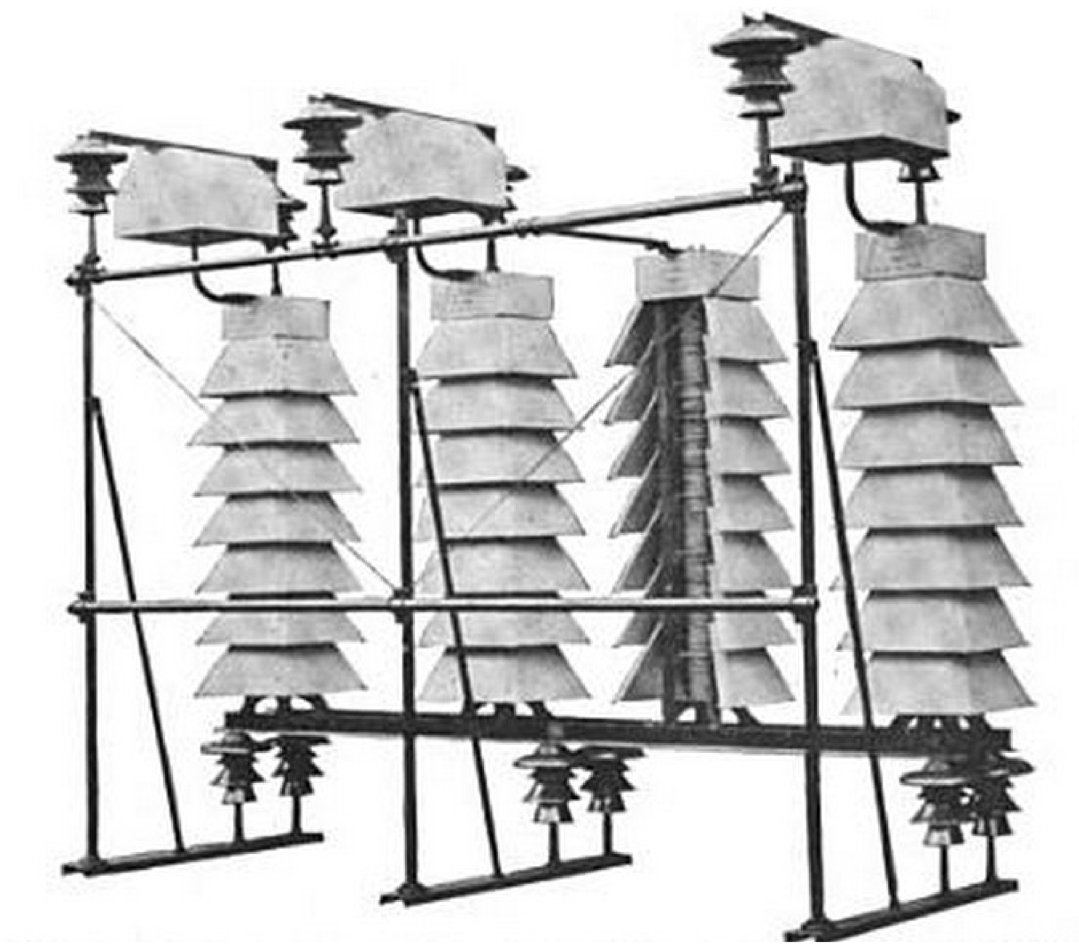
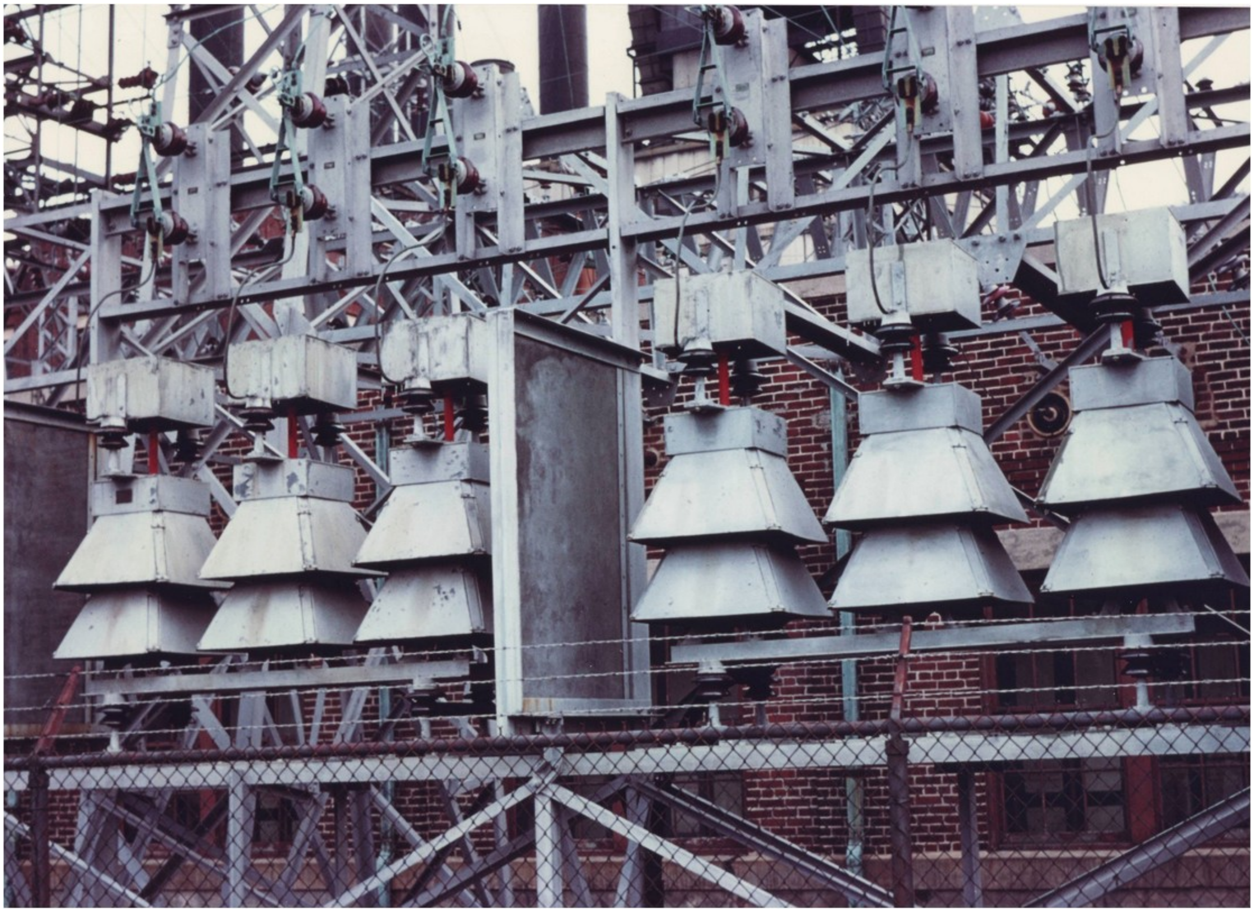
Oxide Film Arrester

An Overview

By Jonathan Woodworth



This arrester was introduced 1914-1919 and discussed in detail in November 1920, AIEE Article .



Oxide Film Arrester
In service in 1969 at the Hauto Steam
Electric Station, Lehigh Valley, Pennsylvania.
Photo by W. Kuhar, Sr.
Photo Contributed to ArresterWorks Virtual Museum
By W. Kuhar Jr.   July 2013

August 12, 1924 *Buying*—POWER—*Section* 105

Cell area 22.7 sq. in.—
All effective
for every discharge

The cell of Oxide Film Arresters has the largest area of any modern valve-type arrester. It is this feature which enables the Oxide Film Arrester to discharge disturbances with appreciable time element so effectively.

General Electric Company
Schenectady, N. Y.
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GENERAL ELECTRIC

33E-49

Alternating-current Lightning Arresters

By V. E. Goodwin

Lightning Arrester Engineering Department, General Electric Company

For a number of years the standard form of lightning arrester has been the electrolytic cell. This cell has a high discharge rate and high electrostatic capacity and is ideal for large power stations where attendants are on hand to look after the charging, etc., that is required. A more recent form of lightning protector is the oxide film arrester. The electrostatic capacity of this cell is lower than that of the aluminum cell and from laboratory data the latter would appear to possess better qualities for protection, but in actual service the relative merits are more nearly equal. The oxide film arrester requires no attention and hence is more suitable for isolated installations. Neither of these arresters offer protection against high frequency surges, and therefore it has been necessary to develop a device known as the high frequency absorber, which consists of a static condenser connected in series with a resistance. High frequency absorbers are installed as auxiliaries to the lightning arresters and are recommended for installation on busbars on the important stations of a system.—Editor.

The purpose of this paper is to discuss recent developments in the art of protecting moderate and high voltage electric stations against lightning and other high voltage phenomena.

Abnormal voltages which are dangerous to electrical apparatus are of two general classes: First, those which exceed the test voltage of the apparatus. These may be either high or low frequency disturbances or single impulses. Second, those of high frequency and low voltage which by virtue of their rapid changes of potential, may build up to dangerous values in inductive apparatus.

For the first class of these disturbances it is necessary to have an arrester which operates instantly upon any abnormal rise in voltage and which has sufficient discharge rate, or conductance, to dissipate the energy of the disturbance at a rate which is faster than it is generated and delivered at that point in the circuit. This question of discharge rate is one which is often overlooked in selecting arresters for a particular service. Many people assume, when they see an arrester spark over frequently, that the arrester is doing a lot of good work. Possibly it is, but sensitiveness is only one requisite, which by itself is of no merit since without discharge rate the excess voltage would not be relieved.

For the past twelve years the aluminum, or so-called electrolytic lightning arrester has been the standard form of protector for large

Fig. 1. Aluminum Cell Lightning Arrester for Indoor Service, 3000-5000 Volts

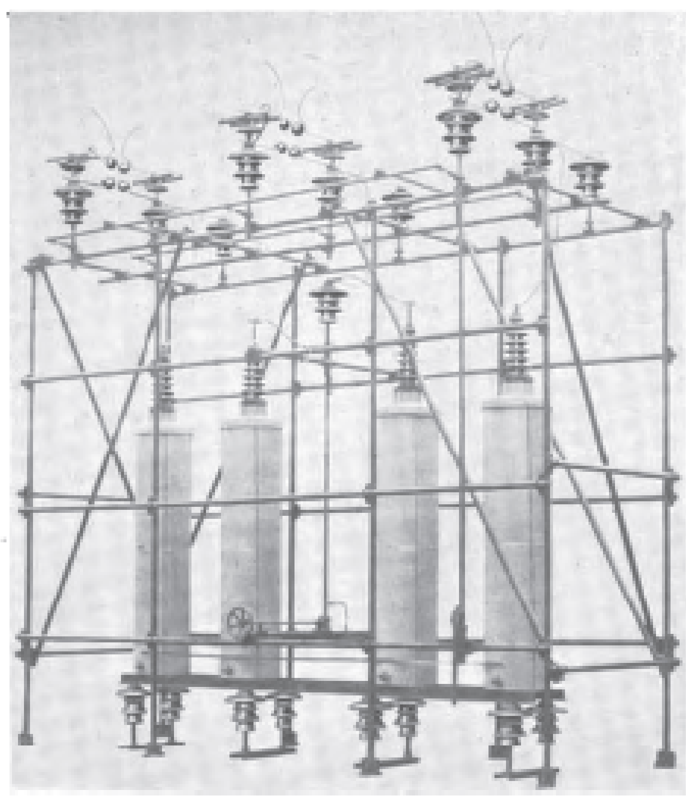


Fig. 2. Aluminum Cell Lightning Arrester for Outdoor Service, 50,000-73,000 Volts

stations. This type of arrester, due to its film or valve action, combined with its high electrostatic capacity per cell, has characteristics which are ideal for this service. This film or valve action of the cells limits the passage of energy current at normal voltage to a small value. If the voltage tends to rise to abnormal values, the current increases rapidly; thus the cells act as a barrier to normal voltage but as a virtual short circuit to the abnormal part of any excess voltage disturbance. By this action the aluminum cell tends to automatically keep the voltage below a predetermined critical voltage at which the apparatus can be safely operated.

The high electrostatic capacity of the aluminum cell is a highly desirable characteristic of a lightning arrester as it provides a ready means for absorbing the energy of any high frequency or steep wave front disturbance, and it also tends to modify the wave form of impulsive voltage disturbances so as to render them less harmful to the system.

A more recent development in this field of protection is the oxide film arrester, previously described in the technical press, (A. I. E. E., June 1918, and G. E. REVIEW). This arrester has many of the characteristics of the aluminum type; namely, the cellular construction, the film or valve action, and the high electrostatic capacity.

While possessing these similar features the two types differ materially in details as well as in operation. The cells of the aluminum arrester consist of aluminum cones or trays, partially filled with electrolyte which forms a film of aluminum oxide on the active surface of the aluminum when current is passed through

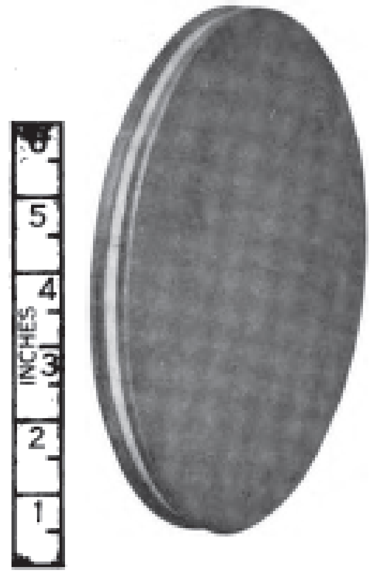


Fig. 3. An Element of the Oxide Film Arrester

the cells. These cells are immersed in a tank of oil for cooling and insulating purposes.

The cells of the oxide film arrester are self-contained and consist of two metal electrodes securely clamped to a porcelain spacer. The

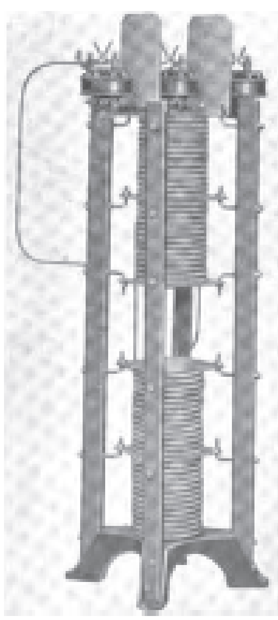


Fig. 4. Oxide Film Lightning Arrester for Indoor Service, 5000-7500 Volts

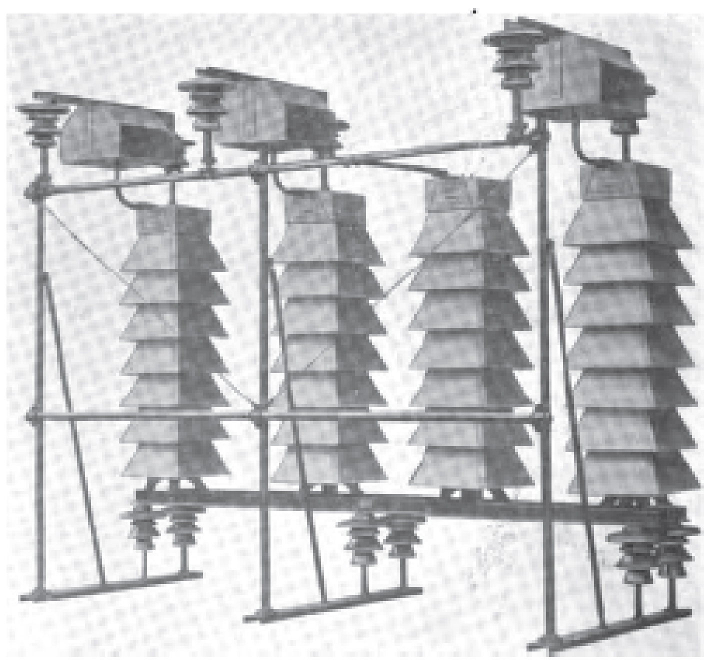


Fig. 5. Oxide Film Lightning Arrester for Outdoor Service, 50,000-73,000 Volts

voltage for its operation and which consequently does not have a series gap. Its function should therefore be to separate and absorb the energy producing the high frequency disturbance.

The high frequency absorber illustrated in Figs. 7 and 8 has been developed to meet this condition. The device consists of a static condenser with a series resistance. The condenser acts as an automatic relief valve for high frequencies and the resistance as a means of absorbing the energy which is tending to produce these oscillations. They are so designed as to pass only small leakage current at normal frequency. If the frequency should increase from some extraneous source, such as an arcing ground, the current through the device would tend to increase nearly in proportion to the frequency if the energy supplying this condition were not limited. This, fortunately, is the case, as the high frequency energy is limited in value. Hence as the current through the condenser and series resistance increases, the resistance absorbs the energy and dampens the oscillations, thus rendering them less dangerous to the system.

The action of the high frequency absorber as described above can be better understood from a study of the following calculations of an actual design.

The impedance of a condenser with a series resistance is

$$Z = R^2 + \left(\frac{1}{2\pi fC}\right)^2$$

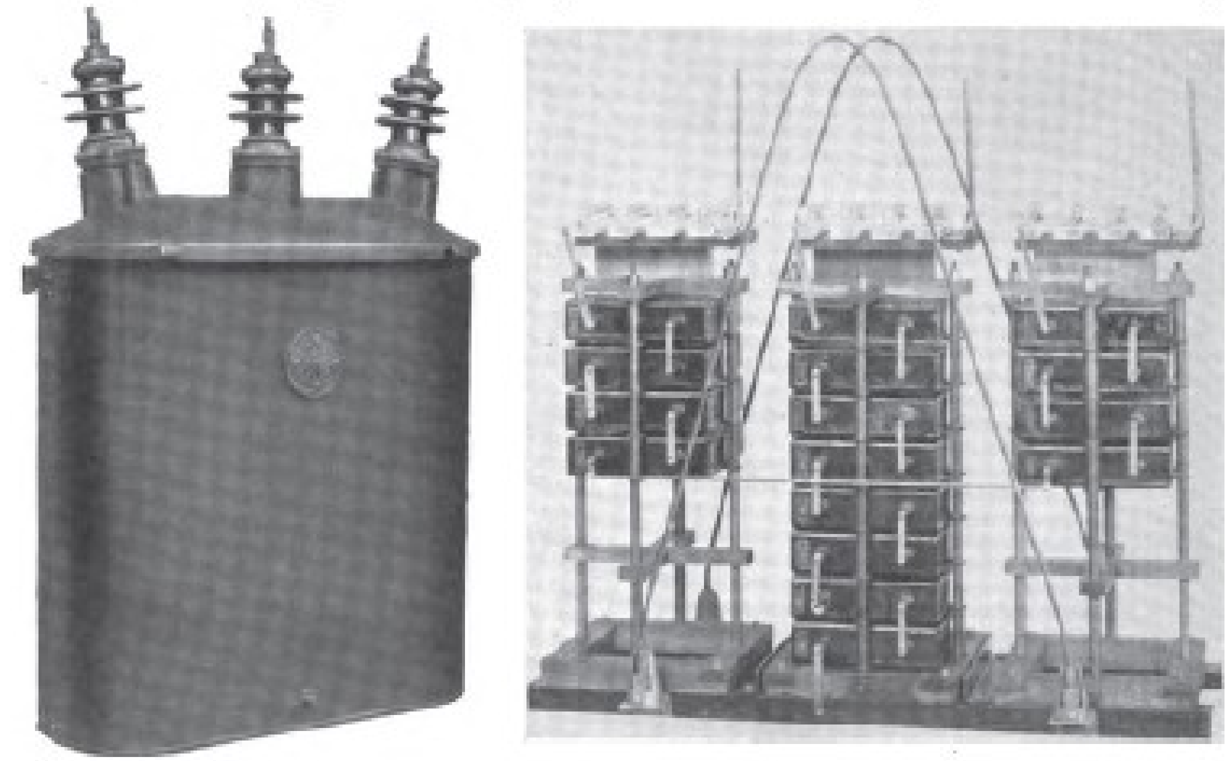
R 100 C .01 microfarads $f = 60$ cycles.

Then Z at normal frequency = 265,000 ohms. At 13,200 volts the current at 60 cycles would be .05 amperes and the energy absorbed by the series resistance would be $.05^2 \times 100 = .25$ watts per second.

For comparison, let us assume that the frequency be suddenly increased to 100,000 cycles, the other factors remaining constant.

Then $Z = 188$ ohms.

At 13,200 volts the current at 100,000 cycles would be 70.3 amperes and the energy absorbed would be $70.3^2 \times 100 = 494{,}000$ watts per second.



Figs. 7 and 8. High Frequency Absorber, 15,000-25,000 Volts

The high frequency absorbers are installed as auxiliaries to aluminum and oxide film arresters and are usually recommended for installation on the busbars of the more important stations of the system. The high frequency absorber illustrated in Fig. 7 has been developed for service on voltage from 7500 to 25,000.

These high frequency low voltage disturbances are most serious on moderate voltage systems, particularly those where the voltage is stepped down from high voltage transmission circuits. On the higher voltage transmission circuits the long lines seem to act as absorbers and to dampen out these disturbances.

Hauto Coal-fired Plant Once Rule

January 31, 1994|by RALPH KREAMER, The Morning Call , Lehigh Valley News

At one time the Hauto power plant of the Pennsylvania Power and Light Co. was the "workhorse of the system."
Although the trend has been toward more modern, economical methods of generating electricity, the Hauto plant once rated as one of the most historically unique of its type.

The power plant predated its ownership by PP&L. It was placed in operation by the Lehigh Coal and Navigation Co. in 1913, seven years before the formation of the local utility.

"MINE MOUTH" PLANT

Built primarily to provide electric power for nearby anthracite mines and the Lehigh Valley cement mills, it was one of the earliest "mine mouth" plants. The idea of this type of plant, conceived by Thomas A. Edison, was to realize convenience and economy by building the power plant close to its source of fuel. In its heyday, this operation was the largest anthracite-burning power plant in the world.
In 1919, Lehigh Navigation merged with several small power companies in the Allentown area and the consolidation came to be known as the Lehigh Valley Light and Power Co. In 1920, Pennsylvania Power and Light Co. was formed by the merger of a number of small electric and gas utilities in the Allentown-Bethlehem lower anthracite and Sunbury-Milton areas. Lehigh Valley Light and Power was one of those companies. Its Hauto plant, with a capability of 30,000 kilowatts, became the second-largest power plant on the newly formed utility's system.

CAPACITY DOUBLED

By 1923, PP&L put two additional units in service at Hauto and more than doubled the capability of the plant. Over the years, subsequent additions and improvements were made so that the capability of the Hauto plant reached an all time high of 125,000 kilowatts by 1943.

At Hauto, anthracite was used exclusively in the production of electric power. Fine coal delivered by truck and rail was dried and passed through three pulverizing mills where it was ground to talcum-powder fineness. The fine coal was mixed with hot air and blown into the furnaces to be burned much in the same fashion as fuel oil. It literally burst into white hot flame, turning the water in the boilers into steam to drive the turbine generators.
Even though the plant's kilowatt output in 1956 was only a fraction of its former production, it consumed more than a quarter million tons of anthracite.

OPERATION CURTAILED

Changing economic conditions after World War II, however, necessitated a curtailment in the operation of the Hauto plant. A continuing increase in electric usage by PP&L customers dictated a need for additional power plants and the company embarked on a multi-million dollar expansion program. Faced with an era of inflationary prices and spiraling costs, the utility knew that if it were to keep the price of electricity at reasonable levels in future years, it would have to go all out in the adoption of new and modern facilities and techniques.

The construction of much larger, more efficient generating units were completed in 1949 at the company's first postwar power plant, the Sunbury Steam Electric Station. Each of the first two Sunbury units had a capability approximately three times that of Hauto's largest generator.

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This was only the beginning. A third unit at Sunbury quickly followed, having a capability approximately four times that of Hauto's largest. Finally a fourth unit was installed at Sunbury, having more capability than the entire Hauto plant.

The second post-war plant was built at Martins Creek, followed by the third plant at Brunners Island south of Harrisburg.

As these big new plants were placed in service after World War II, PP&L retired 33 of the smaller, less efficient, older vintage "kilowatt factories."
Slowly, as the years passed, the Hauto power plant's output decreased. In 1969, after 56 years of operation, this old workhorse was closed. Demolition began in 1973 and took more than three years to complete.