

Fig. 14.—Variation of $\frac{S}{Cp}$ (Power Factor) With Temperature and Frequency for Gutta-percha Condenser.

that part of it denoted by a , is greatly increased by the presence of moisture in the dielectric. This part is probably identical with the true direct-current conductivity.

6. The part of the conductivity denoted by the coefficient a is possibly electrolytic in nature, while the part

proportional to the frequency is a consequence of an energy loss which is possibly analogous to the hysteresis loss in iron.

7. The dielectric constant for alternating electric force is in most dielectrics rather smaller than that for steady or unidirectional electric force. In no case is it larger.

8. In the case of pure India rubber and vulcanized India rubber the temperature coefficient of the dielectric constant may perhaps be negative within the range of telephonic frequencies, and 0 deg. Cent. to 50 deg. Cent., but this result is not quite certain.

9. The ratio S/Cp , nearly identical with the power factor, is, for some dielectrics such as mica and dry paper, a constant independent of frequency and temperature. For most dielectrics it increases with rise of temperature but decreases with rise of frequency. The power-factor variation with temperature of vulcanized India rubber and gutta percha is quite abnormal.

10. Those dielectrics such as celluloid and gutta percha, which have large alternating-current conductivity, although free as far as possible from moisture, also exhibit in a marked manner the phenomena of dielectric absorption and residual charge.

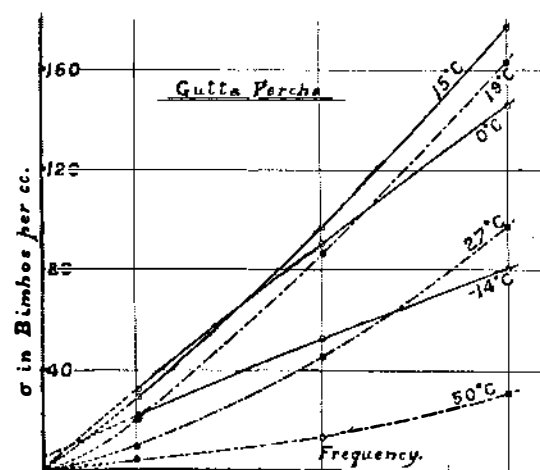


Fig. 15.—Variation of Conductivity With Temperature and Frequency for Gutta-percha.

11. For certain dielectrics there is a temperature at which the power factor and alternating conductivity have maximum values.

The Elusive Will-o'-the Wisp

One of Nature's Unsolved Enigmas

By Charles Fitzhugh Talman

WHAT has become of Will-o'-the-Wisp? As a handy metaphor Will is no less common than of yore. As a physical entity he appears, in this country at least, to have passed into the category of traditional things. The impression prevails that, if he was ever more than a myth, he is now no better than a memory, and that his unearthly light was finally extinguished about the time of our adolescence—which puts him in the same class with the long winters of unlimited sleighing. The reference-books tend to ignore him. You will seek him in vain in the new Encyclopædia Britannica.

Murray's Dictionary (under *ignis fatuus*) says: "It seems to have been formerly a common phenomenon, but is now exceedingly rare." However, this retrospective attitude toward will-o'-the-wisp is by no means confined to our own times. An essay on this meteor in the *Penny Magazine* for July 12th, 1845, begins with the following words: "Most persons are aware of the fact that the moving lights called Will-o'-the-Wisp, or Jack-o'-Lantern, were much more frequently seen and talked of in former years than they are at present." Apparently he was *always* "more frequently seen in former years than at present," for exactly the same reason that the winters of our childhood were longer and colder and more snowy than those of to-day. His presence created a lasting impression; his absence was the normal order of things.

The obsolescence of will-o'-the-wisp in English and American scientific literature makes it necessary for the student to turn to another language, viz., German, to find out just what is known to-day concerning one of the most curious phenomena of Nature. In Germany the "Irrlichterfrage" ("will-o'-the-wisp question") is still actively discussed; although there, as elsewhere, the opinion prevails that the phenomenon was formerly much more common than it is now.

The first scientific account of will-o'-the-wisp appears to have been that given by Musschenbroek, the Dutch physicist, in a work published in 1726. He entertained no doubts as to the reality of the phenomenon; described it about as it is commonly described to-day; but declared that specimens had been captured and found to be masses of slimy material resembling frog-spawn. He believed that they consisted of phosphorus.

In the early part of the nineteenth century the belief in the reality of will-o'-the-wisp was still unshaken; and it was explained—as it still is to-day in the encyclopedias that religiously enshrine the fossilized opinions of our grandfathers—as due to the combustion of marsh-gas, or phosphuretted hydrogen, or both. However, the growing doubts of physicists finally found expression in an appeal from Poggendorff, the famous editor of the *Annalen der Physik und Chemie*, for new observations that might throw further light on the question. In response to this appeal many circumstantial reports of the occurrence of the phenomenon were received. They were published in Poggendorff's *Annalen* from the year 1838 onward, and constitute a most important body of evidence on the subject.

Of these reports the one most often quoted is that from the famous astronomer Friedrich Wilhelm Bessel. He stated that thirty-one years before the time of writing, when he was twenty-three years of age, he had seen will-o'-the-wisp over a moor near Bremen. At the

time of the observation he was in a boat on the Wörpe River, and saw the lights over the partly flooded low-lying land adjacent; he was therefore unable to approach them. They occurred in the form of numerous little bluish flames, which appeared and disappeared; some were stationary, while others moved in groups laterally, so that a companion of Bessel's compared them to a flock of birds. The boatmen declared that they had often seen them before in the same locality.

The example of Poggendorff was followed, in more recent times, by H. Steinvorth, of Hanover. Through the medium of both scientific and popular journals he invited not only scientific men, but the public generally, to send him reports and descriptions of will-o'-the-wisp. In a series of articles published between 1893 and 1901¹ he collected and discussed the numerous replies received from all parts of Germany, and also reprinted a great many contributions to the subject that had been published by others, including those collected by Poggendorff; so that his memoirs are a mine of information. Steinvorth's attitude is, on the whole, skeptical; but he remains open to conviction. He appears to have had a *parti pris* in favor of the firefly explanation; though it is hard to believe that educated men, familiar with fireflies all their lives, should have mistaken these insects, the appearance of which is so characteristic, for *ignis fatuus*.

Another diligent student of will-o'-the-wisp was Hermann Fornaschon, of Lübeck. His writings, the most important of which appeared in 1899,² contain a great number of interesting descriptions of various luminous phenomena, some of which he accepts as genuine cases of will-o'-the-wisp, while others he excludes from that category.

Mention should also be made of W. Müller, of Erzbach, who published useful digests of the will-o'-the-wisp question; the latest in the *Meteorologische Zeitschrift* of November, 1900.

What is Meant by "Will-o'-the Wisp"?

A great number of phenomena, differing widely from one another, have been described as "will-o'-the-wisp." Hence it is difficult to define this term; though this is a necessary preliminary to any attempt to explain the phenomenon.

When we say that various luminous appearances seen by night have been mistaken for will-o'-the-wisp we assume that there is a *real* will-o'-the-wisp—a fact not yet proved to the satisfaction of all students of the question. Some of these appearances are: (1) The phosphorescence of decaying wood ("fox-fire") and other vegetable matter. This is due to luminous fungi. According to Molisch there are some forty-five species of fungus, including about twenty species of bacteria, that have the power of luminosity.³ He has found that moist decaying leaves are often luminous, so that the floor of a forest is sometimes illuminated on all sides with a soft white light from this source. (2) Fireflies, includ-

ing glowworms (the wingless females of the firefly and the larvæ). (3) Luminous birds. Their luminosity is supposed to be due to parasitic fungi.⁴ (4) Ball lightning—a phenomenon that is still as much of a riddle as "real" will-o'-the-wisp, and in some of its manifestations appears to closely resemble the latter. (5) St. Elmo's fire—the brush discharges of electricity so often seen at the tips of masts and spars on shipboard, and at the extremities of various objects, including the human body, in mountainous regions. (6) Moving lanterns, the distant lights of houses, and the other human agencies. (7) Burning gas ascending from marshes, stagnant pools, and the like. Marsh gas and other inflammable gases commonly arise from such places, and are often ignited by human agencies. This phenomenon is witnessed even in the daytime. There is also abundant evidence to prove that these gases sometimes ignite spontaneously. (8) Burning naphtha springs.

By far the greater number of the reported cases of will-o'-the-wisp undoubtedly belong to one or another of the foregoing classes. According to the believers in a "real" will-o'-the-wisp, however, there remains still another class of phenomena, which, though by no means uniform in its details, may be briefly described as follows:

Small luminous bodies, "about as large as your fist," or "the size of a candle flame," are seen hovering a few feet above the ground; not only over marshes and pools, but also over dry land. Sometimes they are stationary; at other times they appear to drift with the wind, or even to move independently of the wind. They appear and disappear, after the manner of fireflies. They do not set fire to objects with which they come in contact, and are assumed to be without sensible heat. Their color is most often described as bluish, but may be yellow, purple, green, etc.; rarely pure white. They are without odor and without smoke. Traditionally they are associated with graveyards, but very few of the immense number of cases recorded by the German writers above mentioned were actually seen in such places. The popular idea that they flee from the traveler who tries to draw near to them and follow him when he seeks to avoid them is also unsupported by the evidence thus far adduced.

A Typical Case of Will-o'-the-Wisp.

From the vast amount of material available the following may be selected as a typical description of "real" will-o'-the-wisp. By way of preliminary it should be stated that, while the majority of recorded observations of will-o'-the-wisp have been made in the summer and early autumn, the opinion prevails, especially in Catholic countries, that this phenomenon is most common at the Advent season, which begins at the end of November. This belief has been explained by Carus Sterne⁵ as arising from the fact that the first mass of this season is celebrated at 5 o'clock in the morning, whence the inhabitants are obliged to be abroad before daybreak, and have unusual opportunities of observing this nocturnal meteor.

Prof. Wenzel Horák relates⁶ that during his boyhood

¹ See T. D. Pigott, "Luminous Owls and the 'Will-o'-the-Wisp,'" *Contemporary Review*, 94, 1908, p. 64-72.

² *Prometheus*, 7, 1896, p. 316-317.

³ *Globus*, 1896, p. 11-12.

⁴ *Jahreshefte des naturwissenschaftlichen Vereins für das Fürstentum Lüneburg*, 13, 1895, p. 1-84; 14, 1898, p. 7-61; 15, 1901, p. 19-44.

⁵ "Kritische Betrachtung der Irrlichterfrage," *Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg*, 53, 1899, p. 34-93.

⁶ *Smithsonian Rept.*, 1905, p. 351-362.

he often saw will-o'-the-wisp at the Advent season over the fields and meadows of his native village of Nemcitz, in Moravia. They were, in fact, familiar to every inhabitant of the village. For eight years he served as acolyte in the parish church, and on his way to the early mass, with various companions, saw sometimes two or three, sometimes as many as twenty or thirty of these lights. They appeared on calm moonless nights, in both clear and cloudy weather. Moving with great rapidity they would sometimes rush together, at other times scatter; spring up and down; appear and disappear; and would continue their pranks until day-break.

"I remember one night in particular," he says; "the weather was fine; the ground was slightly frozen; a little snow lay in the furrows; the air was crisp and dry. Hardly had we left the village when we saw several will-o'-the-wisps dancing over the meadows. One was especially pretty, and was jumping up and down in a lively manner. I pointed to it, with the remark, 'That's a beautiful will-o'-the-wisp.' My companion struck down my finger, saying, 'You must not point at a will-o'-the-wisp; if you do he will molest you.' At that moment the will-o'-the-wisp rushed toward us; halted at a distance of twenty paces, jumping up and down; then retreated and danced about with some others; again approached us; and so on."

Horák says that these lights were often discussed among the villagers, the men generally attributing them to natural causes, while many of the women believed them to be the souls of unbaptized infants; a common superstition in many parts of Europe.

Years afterward—viz., in 1895—Horák revisited his old home, and inquired of an uncle whether the lights were still seen. The latter appeared surprised at the question. "Of course," he replied. "Why should they not be?"

The foregoing narrative will call to the reader's mind the characteristic appearance of fireflies, but there are two objections to this simple explanation: (1) Fireflies are not abroad in December, and (2) dwellers in the country are so familiar with the appearance of these insects that they could hardly mistake them, habitually, for something else.

The Chemistry of Will-o'-the-Wisp.

Granting the reality of will-o'-the-wisp, there are, up to the present time, two plausible, though hardly convincing theories as to its origin.

1. The phenomenon may be a particular manifestation of ball-lightning. This hypothesis, however, only begs the question, for the origin of ball-lightning is still a mystery.

2. Some interesting experiments in the artificial production of will-o'-the-wisp have recently been made by a Belgian chemist, M. Léon Dumas.¹ This *savant* agrees with all other students of the question that marsh gas (methane, CH_4) cannot produce the characteristic appearance of will-o'-the-wisp; it diffuses too rapidly in the air, and, moreover, is not spontaneously combustible. On the other hand, phosphuretted hydrogen (phosphine, PH_3), though it takes fire spontaneously in the air, produces thick wreaths of smoke when burning, and has a powerful odor of garlic, or of putrid fish. Neither of these features has been reported in connection with will-o'-the-wisp.

Dumas accordingly decided to experiment with sulphuretted hydrogen (H_2S) combined with phosphine. In his garden he produced a small quantity of sulphuretted hydrogen, by decomposing ferrous sulphide with sulphuric acid in an ordinary vegetable tin. When this gas was being actively disengaged he threw in a very small fragment of calcium phosphide, the reaction of water on which produces phosphine.

The sulphuretted hydrogen alone produces bubbles of gas that appear luminous in the dark, but the odor of this gas (that of rotten eggs) is powerful and unmistakable. But when the phosphine, disengaged intermittently, sets fire to this gas, a transient bluish flame is produced, without noise or odor, and without the characteristic smoke-wreaths of burning phosphine; and the sulphur dioxide (SO_2) produced by the oxidation of the sulphuretted hydrogen (H_2S) causes the precipitation of sulphur in the form of an impalpable powder. The whole forms a little luminous cloud that floats away and, according to Dumas, presents altogether the appearance commonly assigned to will-o'-the-wisp.

Both phosphine and sulphuretted hydrogen are produced in the decay of animal substances. The brain and the spinal cord are rich in both sulphur and phosphorus. The body of an animal, buried in some wet place, would accumulate the two gases in question under pressure in the skull and spinal canal; and being of nearly the same density they would force their way out simultaneously or nearly so. Thus it appears possible that "real" will-o'-the-wisp may arise from the decomposition of the bodies of animals; a belief that has long been

held, but the *rationale* of which M. Dumas seems to have first made clear.²

Science Notes

The Persistence of Typhoid Bacilli After Recovery.—It is well known that a person may harbor typhoid bacilli in his body for a long time after recovery from the disease. An extreme instance in point is cited in *Cosmos* typhoid germs having been found in a cyst operated upon thirty-eight years after recovery of the patient from typhoid.

Carbon From Coal Tar.—It is reported in the *Revue électrique* that a Stockholm firm is successfully working a process for separating carbon from coal tar; the black color of this is due to the presence of fine particles of suspended graphitic carbon. The material thus recovered should be well adapted for lamp carbons, crucibles and the purposes for which graphitic carbon is commonly used.

Domesticated Elephants in Siam.—The number of tame elephants in Siam is estimated at 3,000. These animals give most valuable services, and it is greatly to be regretted that they are diminishing in numbers. As a consequence of this their price is increasing. At the present time a male fetches about \$2,500 and a female \$1,800. The elephant is mature at twenty-five, reaches its full vigor at thirty-five, and lives to an age of eighty-five to a hundred and ten years.—*Cosmos*.

Mammoth Fat.—The Russian chemist Chestakow has made an examination of the fat contents of the mammoth cadavers, found in the Siberian ice. It proved to be surprisingly low, compared with the amount of acids present. At the low temperature and in the absence of micro-organisms, the conversion of the original fat into fatty acids had been accomplished by the sole agency of light and air. The fat of these extinct animals differs from that of the present day animals principally in its lack of stearic acid.

The Use of Calcium Carbide in Surgery.—Among the varied uses which calcium carbide has found must now be numbered that of surgical cautery and dressing for wet sores. Dr. Desguins, as reported in *Cosmos*, recommends calcium carbide on the following grounds: 1. It does not attack the sound, dry skin; its effect remaining localized and being, moreover, naturally graded in proportion with the degree of moisture of the affected portions. 2. It does not cause much pain, and has a hemostatic and antiseptic action, while being free from toxic effects. Good results are said to have been obtained in the treatment of malignant tumors.

The Use of Saccharine.—In the majority of countries the use of saccharine is prohibited, except as a therapeutic agent. There are, however, a few exceptions, such as Egypt. In such cases we have means of observing what would happen if the use of the substance were generally permissible. In Egypt saccharine is employed especially in the manufacture of aerated waters. The consumption of lemonade and similar drinks at Cairo is enormous, reaching a million bottles a year. In order to obtain the requisite sweetness, 20 centigrammes of saccharine per liter must be employed. Hence, Cairo alone consumes over 300 kilogrammes (661 pounds) of saccharine, which takes the place of 165,000 kilograms (363,000 pounds) of sugar, that is to say, 550 times the weight of saccharine. The chemist of the Khedive found that out of twenty lemonades, submitted from different sources, only one was sweetened with sugar. The publication *Cosmos*, from which this note is taken, does not mention that any ill effects have been observed as resulting from this very extended use of saccharine.

Why the Hungry Man Tightens the Belt.—With the steady increase in the price of food-stuffs, the following scientific investigation on the suppression of hunger, taken from *Vossische Zeitung*, may doubtless be of general interest. Remembering the habit of tramps to tighten their belts when hungry, Prof. Dr. Rudolf Lennhoff decided to investigate the efficiency of this simple remedy in actually suppressing hunger. Assisted by physicians he made use of the property of the X-rays of being arrested by metals and their salts. Persons were given drinks which contained in suspension salts of bismuth or levigated lodestone, or they were required to eat solid food, such as mashed potatoes, which had previously been mixed with metallic salts. The following results were obtained: In the case of solid food, a contraction of the stomach could be observed, and a relatively small quantity proved to be sufficient to satisfy the appetite. When liquid food was given in the ordinary way, i. e., by swallowing, the contraction was

¹ A similar explanation, though in less precise terms, was offered by T. L. Phipson, in *Belgravia*, v. 6, 1868, p. 392-398. The experiment of Dumas, described above, has been repeated at the Bureau of Standards, in Washington, at the request of the writer of the present article, but with only partial success. Explosive flames are readily produced in the containing vessel, but the puffs of white smoke given off are hardly, if at all, luminous. Perhaps the laboratory conditions do not reproduce with sufficient fidelity those of Nature; however, we believe will-o'-the-wisp is still "elusive."

considerably less, and a larger quantity was necessary for satiation. In a third experiment the liquid was introduced into the stomach through a tube; in this case twice the quantity of liquid was required. These experiments showed that the mechanical stimulus of swallowing by reflex action causes a contraction of the stomach, thus accelerating satiation. This suggested that by artificially increasing the pressure on the stomach satiation could be accomplished with a smaller quantity of food. The trick of the hungry tramp was therefore resorted to, and a belt was applied tightly around the waist of the eater. The result was as anticipated. To make sure and exclude any influence of suggestion, the same experiments were made on insane persons who were allowed to eat as much as they pleased. The result was in all cases the same, they all ate less when the belt was strapped tight around their waist. Other experiments were then made on persons who were given the prepared liquid food through a tube introduced into the throat. In all these cases the belt had no effect whatsoever. The sense of satiation is therefore influenced by the act of swallowing, which causes a contraction of the stomach.

ERRATUM:—We wish to correct an unfortunate error in the caption of the illustration (Fig. 1) of Prof. Carpenter's paper on the Shumann Haines low-pressure engine. In the caption this is referred to as a "turbine." The engine is, of course, of the reciprocating type.

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¹ La Nature, 38, 1^{er} semestre, 1910, p. 30-31.