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Telling Time for the Electrified: An Introduction to Porcelain Insulators and the Electrification of the American Home

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ABSTRACT

As archaeologists increasingly survey and excavate at sites from the late 19th to the mid-20th centuries, they more commonly encounter artifacts that the standard guides do not consider. Included in this class of "too recent" artifacts are the material remnants of the early electrification of the American household. Particularly ubiquitous electrical artifacts are the small white porcelain knobs, tubes, and cleats used in "knob and tube" wiring systems. Meticulous research by insulator collectors, notably Jack Tod and Elton Gish, is a significant boon to the archaeologist, and their work shows that these artifacts can often be dated and provenanced. This article introduces some of the social and material aspects of electrification that are particularly relevant to the archaeologist, and elaborates on electrical porcelain used in the wiring of buildings—one class of artifacts out of several related to electrification.

Introduction

During the period of approximately 1880–1930, rapid developments in materials and distribution technologies transformed electricity from a feared and, for some, ostensibly magical novelty into a widely available, much-discussed, and must-have commodity. Scientists had experimented with electricity since the 17th century, but it was not until late in the 19th century that they would manage to generate and deliver it in a viable manner to people who would have practical uses for it (Edison 1885). Electrification's spread followed the precepts of modern capitalism: it was privately owned and delivered to paying customers. These customers were primarily in urban centers: beginning with municipalities (for street lighting) and wealthy home owners in the 1880s, trolley companies in the 1890s, and factories and department stores in the 1900s. The gimmick of attracting shoppers to electrically lighted store displays lost some momentum once electricity became more affordable and widely available to the average urban homeowner in the 1910s. See Table 1 for "milestones in electrification."

Most American townspeople and farmers lived with the now seemingly archaic oil and gas lighting for some time longer. Although some homes and farms had personal generators or battery-operated appliances, for the most part rural areas, except for settlements and buildings fortuitously located near existing transmission lines, stayed "in the dark" until the second half of the 1930s. It would take federal government action in the form of Roosevelt's 1935 New Deal-inspired Rural Electrification Administration to kick start the unprofitable process of providing electricity to the country's planters and townspeople. The impact of the arrival of electricity to the American home should not be underestimated. As Schroeder (1986) suggests, electrical technology led to the "conversion of our nation's households from hand labor and inconvenient fuels to automation and boundless flexibility."

This period, as archaeologists of the more recent past are well aware, is part of an extended moment that saw a formidable increase in the amount of things designed, patented, manufactured, distributed, discarded, and generally available to the discerning consumer. A second industrial revolution—this time electrical—was under way. The moving assembly line was perfected by about 1915, and with it Model T automobiles and many other products were being manufactured at faster rates and in greater numbers than ever before. The industry producing the infrastructure for electrification was no different from any other industry of this period. Once the electrification of the average American household became the norm, competing companies produced many competing products.

The variability of available products, however, does not stop productive analysis of the material culture of turn-of-the-century electrification. Patterns of use do emerge. Some forms were more successful than others, and those became standardized. When Thomas Edison experimented

Table 1. Electrification milestones.

Year	Event	Source(s)
1865	Production of pin-type glass electrical insulators begins	Miller 2000:15
1876	Arc lighting first used in public areas and streets	Woodhead et al. 1984:75
1879	First practical incandescent light bulb	Devine 1983:354
1882	Direct current (DC) first marketed as a commodity	Devine 1983:354
1882	Incandescent light bulb commercially available	Nordhaus 1997:37
1882	Introduction of cords, plugs and receptacles	Schroeder 1986:526
1883	First electric motors used in manufacturing	Devine 1983:353–354
1884	First steam powered electric turbine	Devine 1983:354
1886	Alternating current (AC) available for lighting	Devine 1983:354
1888	First electric trolley	Hilton 1969:124
1888	First AC motor	Devine 1983:354
1890	Edison first mass manufactures light bulbs	General Electric 2010
1891	First AC power transmission for industrial use	Devine 1983:354
1897	National Electrical Code (NEC) first published	Tod 1977:15
1904	Invention of the parallel two-blade plug	Schroeder 1986:531–532
1904	Introduction of appliances connected to lamp sockets	Schroeder 1986:542
1904	First electric underground trolley (subway)	Hilton 1969:127
1917	Sockets standardized to two-blade style and T-shaped	Schroeder 1986:536, 542
1922	Red neon lights appear in commercial advertising	Woodhead et al. 1984:77
1931	End of lamp-socket appliances	Schroeder 1986:542
1935	Sports played under lights at night for first time	General Electric 2010
1935	Rural Electrification Administration (REA) established	Nye 1990:24
1950s	High intensity incandescent lights used in public areas	Woodhead et al. 1984:75
1962	First three-pronged (grounded) plug	Schroeder 1986:542

with different methods for connecting a light bulb to its power source, his screw-in base approach was only one idea from a field of competitors vying to solve this potentially lucrative problem. Edison's 1881 screw-in base did become the standard, and remains the same to this day. (Edison's success also created the social space for decades of bad jokes.)

The light-bulb socket struggle was an early "format war," akin to the later battles of the 8-track tape versus the compact cassette in the 1970s, and of Blu-ray DVD versus HD DVD in the 2000s (the compact cassette winning the former, and Blu-ray the latter). Even in Edison's lifetime there were format battles fought over everything from the shape of plugs and sockets—parallel two-blade versus T-shaped (Figure 1)—to whether direct current (DC) or alternating current (AC) would most efficiently and safely deliver electricity to the consumer (Schroeder 1986). Confusion over competing formats would come to be lessened significantly through Herbert Hoover's drive for standardization in industry and technology (Hoover 1924).

Early American Electrification and the First Electrical Porcelain

For effective generation, transmission, and end use of electricity to occur, every electric circuit requires an arrangement of conductors and insulators. The *conductors* allow electricity to flow, and the *insulators* block that flow. A copper ingot, for example, makes an excellent conductor, and a piece of glass or plastic makes an excellent insulator. Electrical wire might be described as an *insulated conductor*, since the inner conducting material (metal wire) is sheathed in an outer insulating material (generally paper, cloth, or plastic). A light switch is a great conductor when toggled

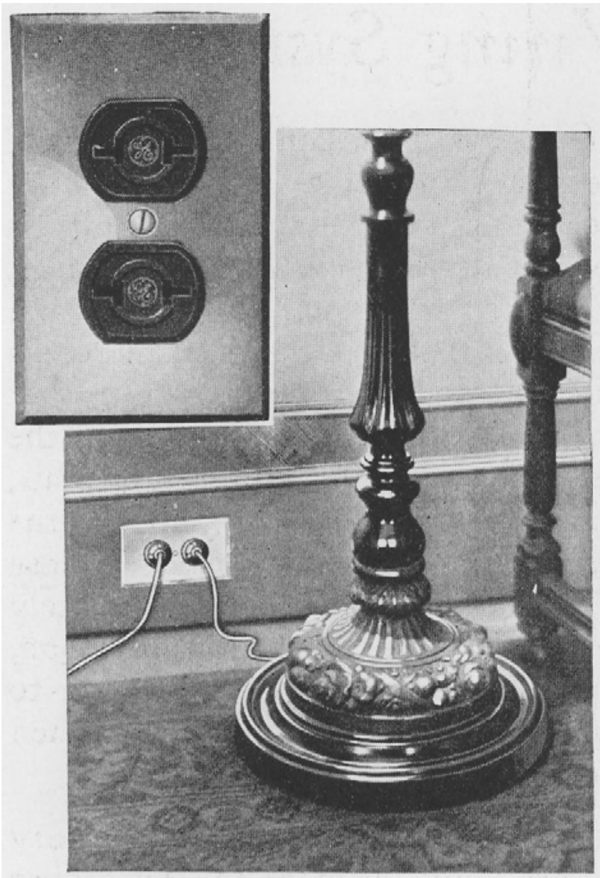


Figure 1. T-shaped plug receptacle (General Electric 1925:34).

to the "on" position. A *resistor* is any component that, by design, introduces a resistance to the flow of electricity. The filament in an incandescent light bulb, though not a resistor per se, is more resistive than the electrical wire leading to it. It resists the flow of electricity in the circuit and thus turns electrical energy into heat and light energy.

Electrical potential is most simply defined as the difference in electrical charge (measured in volts) between two points in a circuit, and a *short circuit* may be defined as an unintentional, and potentially damaging, connection between two points in a circuit. If there is ever insufficient insulation or very low resistance between two points of different potential in any electrical system, there will be a flow of excess current and a short circuit will occur; thus, if the two metal wires bringing electricity to a household are improperly insulated from each other and come into contact, there will be a short circuit. Since a short circuit marks the end of the successful transmission of electricity, it is paramount that electrical wires and components be sufficiently insulated wherever the system calls for it. It is, of course, equally important that the conductors conduct. See Powell (1995:10–39) for a general introduction to electricity and electric circuits.

Some early experimentation in delivering electricity to customers used insulators made of wood and other materials to separate wires from each other and wires from poles and building materials. This practice, common during the period of approximately 1880–1890, seemed perhaps a logical extension of the use of wooden insulators in wiring for telegraphs. Wood is, in fact, a decent electrical insulator, but only when it is perfectly dry. Wood is a porous material and thus absorbs water easily; and since water is a good conductor, a wet wooden insulator will likely short circuit. A second problem with using wood as an insulator is that, though dry wood is an adequate insulator of electrical current, it catches fire at a relatively low temperature. A short circuit in an unfused or poorly fused circuit will quickly generate significant heat, and heat emanating from metal wires attached to wooden insulators leads to fires. An article in an 1892 trade magazine discussed the fact that fire insurance companies were beginning to demand that insulators be made of porcelain rather than "wood, now in general use" (Tod 1977:12). Initially, individual insurance companies set their own standards for electrical wiring. In 1895 there were at least five recognized standards (Grant 1995:95). This changed in 1896, when insurers cooperated to form what is now known as the National Fire Protection Association, which released the first National Electrical Code in 1897. Porcelain, as was soon acknowledged, is cheap, strong, nonflammable, and highly resistive to the flow of electricity; and thus with the support of the insurers it found many electrical applications, as indeed it still does today.

During the mid-1890s, pressure from fire insurance companies resulted in increased regulation and standardization of electrical components. This, combined with a general increase in the number of customers eager for electricity, created significant demand for insulators made of porcelain, or "electrical porcelain." This marked the beginning of what would come to be known as "knob and tube" wiring, the predominant method of wiring buildings from about 1890 to 1930 (Figures 2–14). In knob-and-tube wiring, "knobs" (Figures 2–6) and "cleats" (Figures 3 and 7–9) were used to run wiring along walls, ceilings, and beams, and "tubes" (Figures 6, 10, and 11) were used to run wires through beams. The simple principle of the three forms is that they insulated flammable wooden building materials from the electrical and heat potential inherent in the electrified wires. Excerpts from a 1917 textbook on electrical wiring are useful here:

> The cheapest form of concealed wiring is the knob and tube system. The wires are run beneath the floors or in the partitions and are supported on porcelain insulators or knobs where the wires are run parallel to the floor joists or studding, and pass through porcelain tubes where crossing beams, partitions, etc. (Cook 1917:206).
>
> The system is used chiefly in frame buildings (dwellings, etc.), where a cheap piece of work is desired. The use of the knob and tube system is prohibited by the local rules of many large cities. It cannot be used for fire-proof buildings or for damp places. With this system, the wires are not protected from mechanical injury, and there is always the possibility that they may be damaged by workmen during construction or by rats after the house is in use. The wires may sag against beams, lath, etc., or they may be covered by shavings or other inflammable material during construction so that an overheating of the wires or a short circuit might start a fire (Cook 1917:207).
>
> The knobs may be either solid or split…and must keep the wires at least 1 in. above the surface wired over. Knobs are generally held by wire nails using a leather washer or nail head to prevent breaking the knob. The tubes have a head at one end to prevent their being displaced. The wire used must be rubber-insulated (Cook 1917:207).
>
> In running the circuits, the wires must be kept as far apart as possible, separated at least 5 in. and run on different studding wherever possible. The wires must be supported at least every 4.5 ft and at shorter intervals if they are liable to be disturbed (Cook 1917:208).
>
> This system is used for small branch circuits, where appearance is of no importance, as in cellars, and also used frequently for heavier circuits, for factories (Cook 1917:209).
>
> The advantages of open wiring are that it is cheap and accessible and can be easily changed as required. On the other hand, the wires are not protected, and are liable to mechanical injury (Cook 1917:209).

Being the cheapest and easiest form of electrical wiring, knob and tube ruled the electrification of America through the 1920s. The knob-and-tube boom, however, ended abruptly with the onset of the Great Depression in 1929, when new construction halted and another round of more rigid building codes was widely instituted (Grant 1995). Interestingly, changing perceptions and standards of fire safety mark both the beginning and the end of knob-and-tube wiring. Knob-and-tube wiring continued to be used in some, especially rural, areas until about the 1950s, and remnants of this type of wiring system are to this day commonly seen in basements and attics across America (Figure 2).

Electrical Porcelain Manufacture

Electrical porcelain was manufactured either by the "wet" process or the "dry" process. The wet process used wet clay and either multipart molds (for knobs and cleats) or extrusion (for tubes), and the dry process used drier clay and multipart molds. The dry process produced porcelain that was more porous, and thus less insulating, than the wet process, the result being that only wet process–produced porcelain was used for high-voltage applications. Knobs were almost always finished with a white or clear glaze, and cleats were sometimes glazed and sometimes unglazed. Early tubes were glazed brown or a grayish white, and later tubes, typically after 1900, were mostly unglazed. Additionally, in some catalogs glazed tubes cost about 50% more than unglazed tubes. The porcelain was kiln fired, most commonly in beehive-style kilns.

Research to date suggests that ascertaining the method of manufacture of electrical porcelain artifacts is not useful for identifying the manufacturer or for dating these artifacts. Spurred on by companies in competition with each other, over time innovation seems to have occurred more in the features and functions of electrical porcelain items than in their composition or method of manufacture. The brief summary of manufacture above is based on Tod (1977:63–67), and the reader is directed to that reference for a more in-depth treatment of this topic.

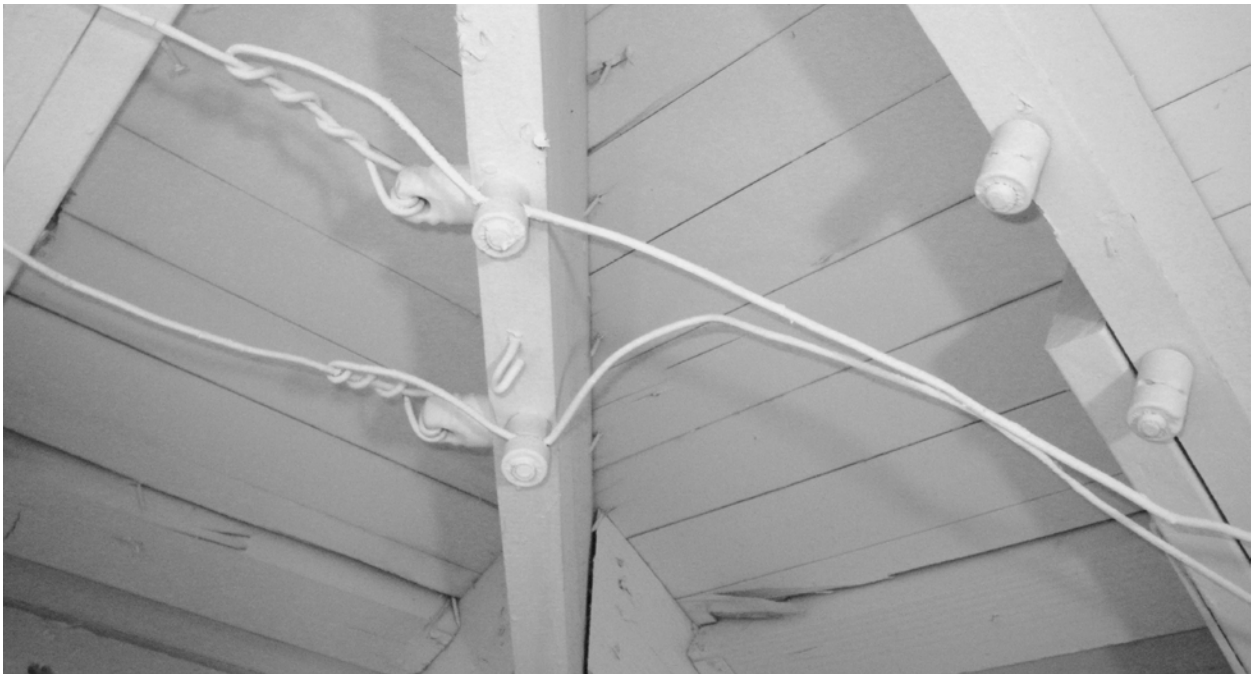


Figure 2. Disused knob-and-tube open wiring above the author's desk at the Stanford Archaeology Center. (Photo by author, 2010.)

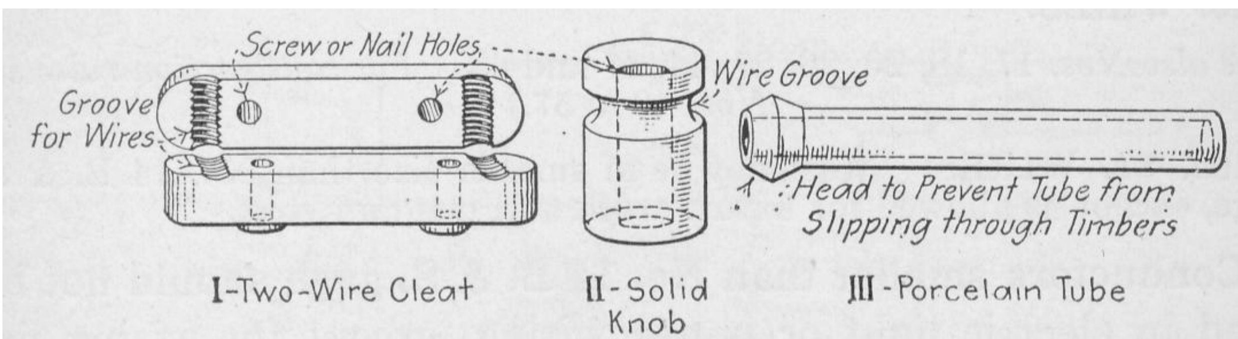
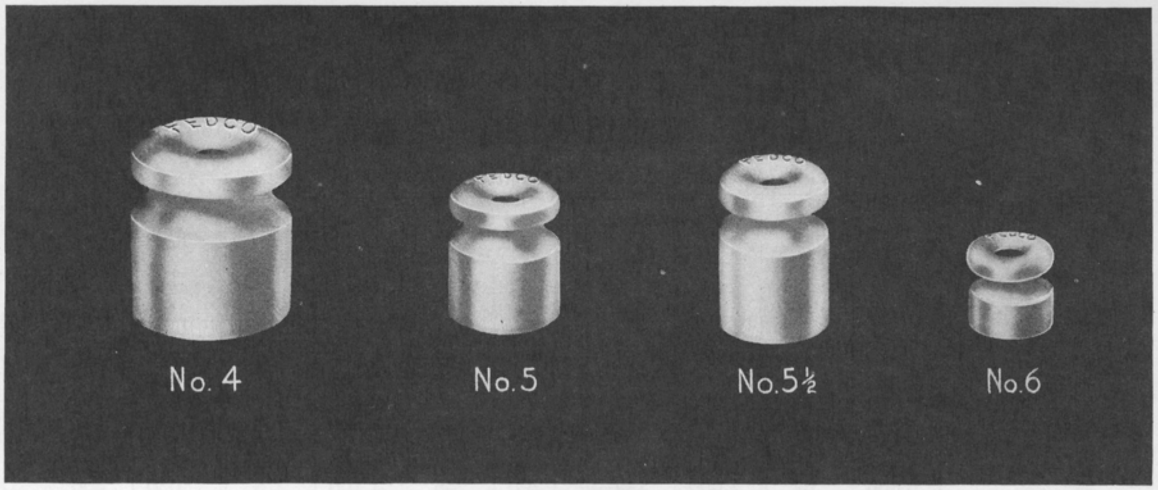


Figure 3. Illustration of a cleat, a knob, and a tube (Croft 1920:172).

Figure 4. Nail knob with nail still present, excavated at Stanford University, courtesy of Laura Jones. (Photo by author, 2010.)

FEDCO The FEDERAL PORCELAIN COMPANY FEDCO



SOLID KNOBS

WHITE GLAZE STANDARD

Catalog Number	Height, Inches	Diameter, Inches	Hole, Inches	Groove, Inches	Quantity per Barrel	Shipping Weight, Lbs. per Barrel	Code Word	Price per 1,000
4	1 11/16	1½	3/8	3/8	2,200	490	Abroad	$22 00
4, 2-groove Tel. Knob	(See Telephone Knobs, page 13.)							
*4½	1 7/8	1½	3/8	7/16	1,900	475	Abscond	25 00
5	1¼	1	¼	5/16	6,000	480	Absence	13 00
5½, Old Code	1 9/16	1	¼	5/16	5,300	500	Abstract	13 00
5½, New Code	1¾	1 1/8	¼	5/16	4,500	500	Accede	16 00
6	7/8	13/16	7/32	¼	13,000	490	Accept	11 00
7	¾	7/8	¼	7/16	15,500	425	Acceptance	13 00
8	15/16	1	¼	5/16	9,000	475	Access	13 00
9	1 1/8	5/8	3/16	3/16	15,000	475	Accident	16 00
10	1¾	1 5/8	3/8	3/8	2,000	490	Accommodate	30 00
*10½	1 7/8	1 5/8	3/8	3/8	2,000	490	Accompany	30 00

* At request of the Government, manufacture will be discontinued after stock on hand is exhausted.

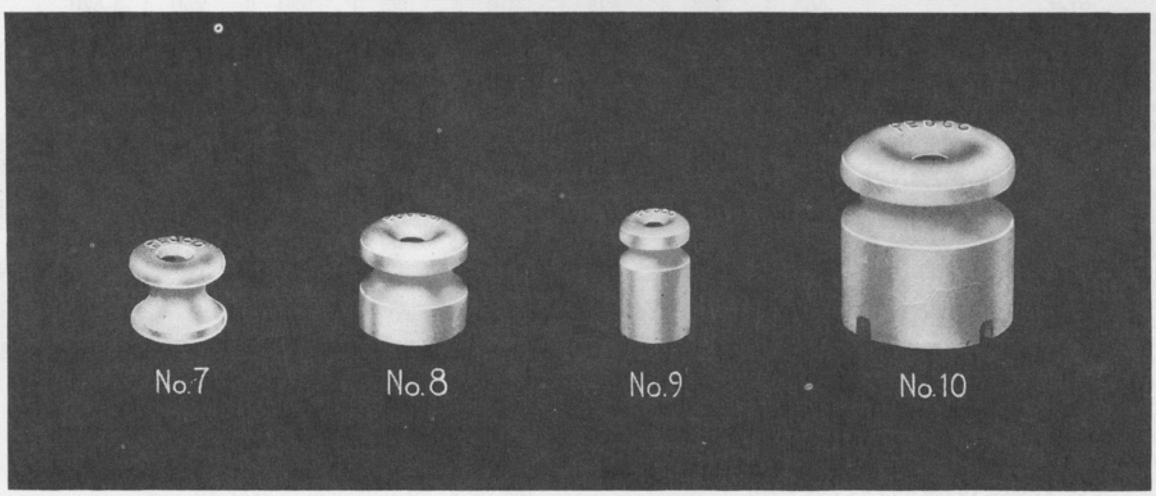


Figure 5. Page from a porcelain-knob supply catalog (Tod 1977:44).

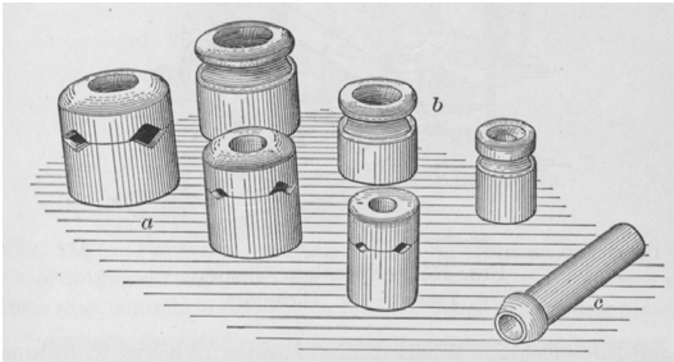


Figure 6. Split knobs *(a)*, solid knobs *(b)*, and a tube *(c)* (Cook 1917:209).

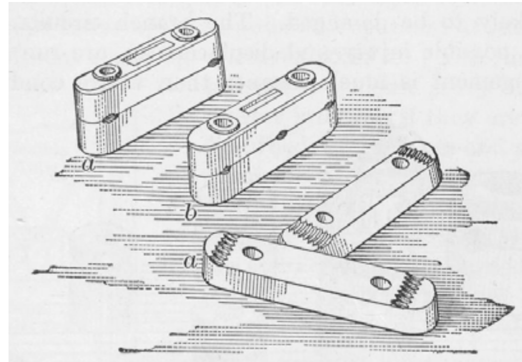


Figure 7. Two-wire *(a)* and three-wire *(b)* cleats (Cook 1917:211).

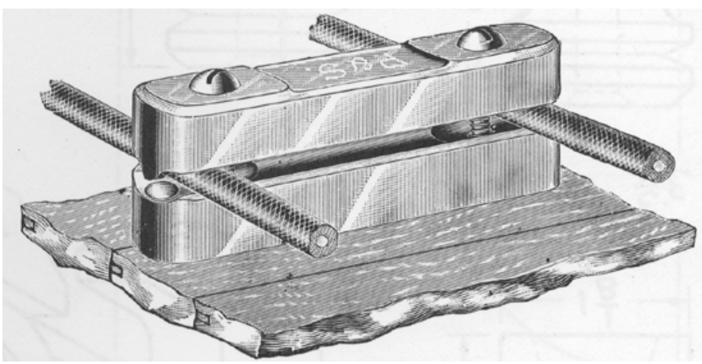


Figure 8. Illustration of cleat with wires in use (Tod 1977:28).

Figure 9. Three cleats excavated at Stanford University, courtesy of Laura Jones. (Photo by author, 2010.)

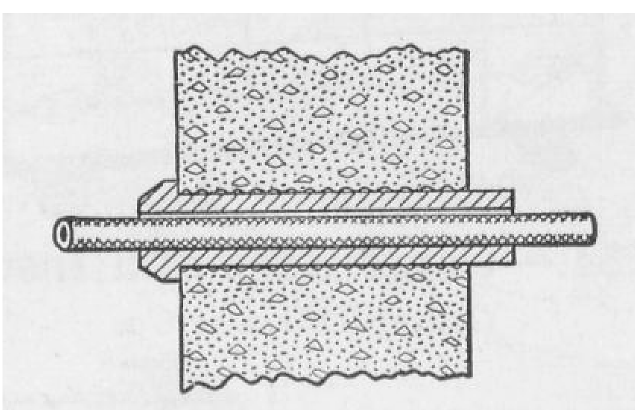


Figure 10. Illustration of the placement of a tube through a stud (Cook 1917:212).

Figure 11. Four tubes excavated at Stanford University, courtesy of Laura Jones. (Photo by author, 2010.)

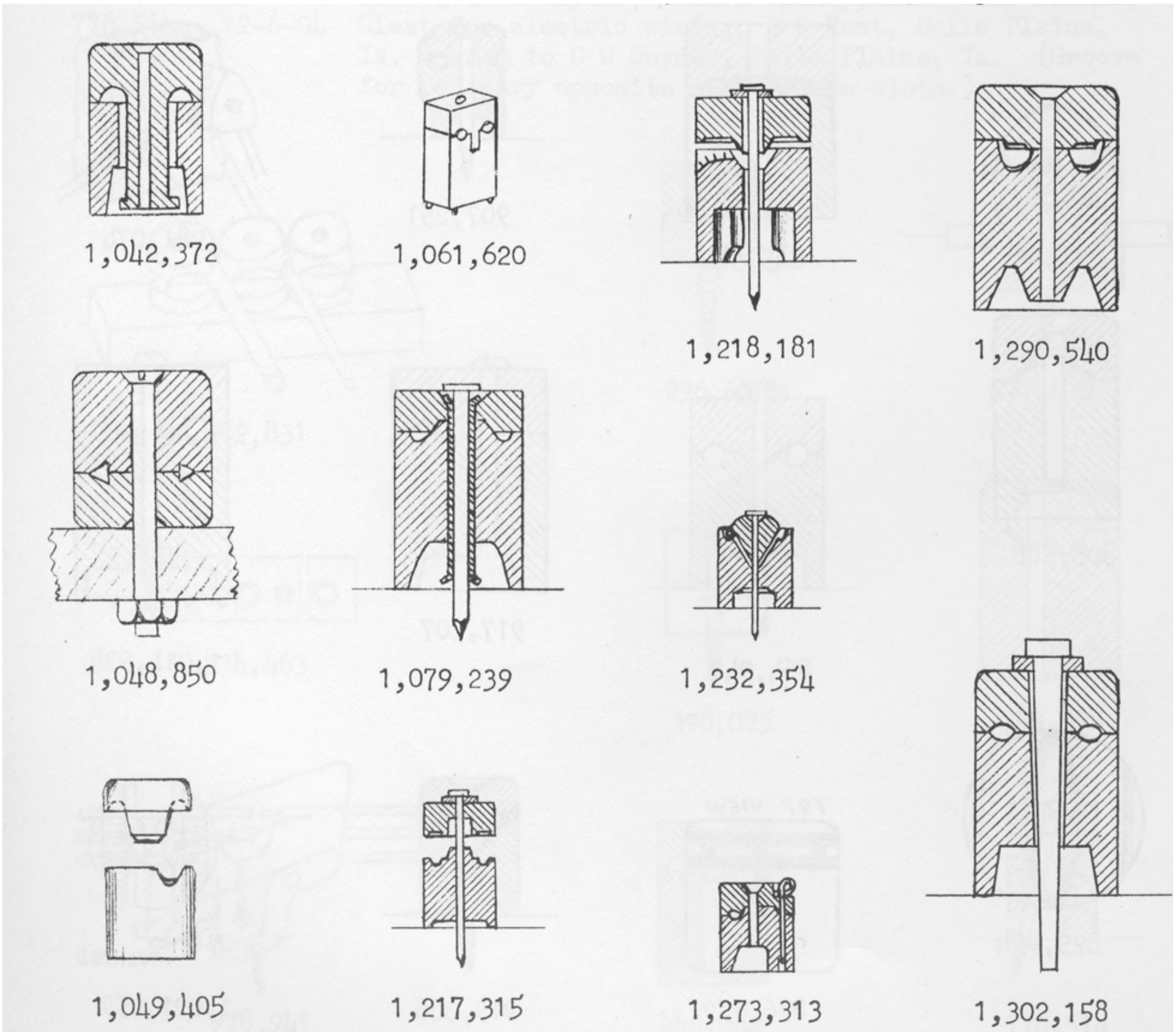


Figure 12. Example of drawings of knobs available in Tod (1977:132).

Dating Electrical Porcelain

The key to dating household electrical porcelain artifacts is through the combination of identifying the style of the porcelain artifact and the maker's mark, when present, and cross-referencing this information with the known dates of introduction of styles and the known start and end dates of use of particular makers' marks. Additionally, companies' trademarks were registered with the U.S. Patent Office and appeared in advertising and catalogs, and sometimes on the insulators themselves; and thus at times these can provide a date of introduction for a particular item (Tod 1977:168–169). Whether one can find only a start date, or both a start and end date, depends entirely on what information exists and is found about a particular company and its markings. Although an electrical porcelain artifact can often be dated with some accuracy, it must be noted that the precision of dating sites and contexts conclusively based on electrical porcelain is hindered by the potentially long use life of these artifacts.

Porcelain Insulator Styles

The history of electrical porcelain during its peak popularity is one of rapid invention and continuous patenting, as

KOLUX	Kollarth Bros, Schenectady, NY, sign insulators
KONDU-BOX	unattributed, end outlet bushings
K.P.	Bryant Electric Co, Bridgeport, Conn, rosettes
KRETZER BRAND	St Louis Lightning Rod Co, St Louis, Mo, lgtng rod access.
KUHLMAN	Kuhlman Electric Co, Bay City, Mich, primary fuse cutouts
KWIKON	Fralick & Co, S R, Chicago, wiring devices
L or L	unattributed, wireholders
L	unattributed, wireholders
L	unattributed, rack, clamp, wireholder insulators
LEVITON	Leviton Mfg Co, Brooklyn, standard porcelain & specialties
LF or LF	L F Mfg Co (Louis Fort), Jersey City, NJ, clamp insulators
LINGO	unattributed, specialties
LITTLE GEM	Pass & Seymour, Inc, Syracuse, NY, rosettes
L.M.	Line Material Co, Milwaukee, Wis, poleline hardware
LM or LM	ditto
LOCK SHELL	Hubbell, Inc, Harvey, Bridgeport, Conn, switches, sockets
M or M	Illinois Elec'c Porc Co, Macomb, Ill, stand porc & speclty
M	unattributed, wireholders
MACOMB	Illinois Elec'c Porc Co, Macomb, Ill, standard porcelain
MANDICO	Manufacturer's Distributing Co, New York, sign receptacles
MANHATTAN	Manhattan Elec'l Supply Co, Inc, New York, wiring devices

Figure 13. Example of electrical porcelain makers' marks available in Tod (1977:110).

Figure 14. Factory worker "turning" knobs for uniformity (Tod 1977:39).

dozens of competing manufacturers aimed to enter the market, each with its own slight variation on the standard shapes and sizes of porcelain insulators. Sometimes the approximate dates of introduction (TPQs) of these different styles of insulators are accessible through patent records and product catalogs. Exhaustive information on the dates of introduction of various styles is available from two excellent sources: a website maintained by insulator researcher and collector Elton Gish (<http://www.r-infinity.com>), and *A History of the Electrical Porcelain Industry in the United States,* a self-published book by Jack Tod (1977). Tod's book is the most comprehensive published collection of ceramic insulator styles (Figure 12). Note that these sources are principally, if not exclusively, applicable to the United States.

Table 2. Electrical porcelain milestones.

Year	Artifact / Event	Source
1880	Beginning of porcelain cleats boom era	Tod 1977:14
1883	One-piece cleat	Tod 1977:129
1884	Split-knob	Tod 1977:13
1885	Crossover style knob	Tod 1977:141
1885	Multipiece cleat	Tod 1977:127
1889	Self-tying knob	Tod 1977:137
1890	Beginning of knob-and-tube boom era	Tod 1977:7
1891	Reversible wire cleat	Tod 1977:126
1892	End of use of wood for wiring insulators	Tod 1977:12
1892	Two-wire cleats	Tod 1977:13
1892	First wall tube	Tod 1977:15
1897	Standardization of electrical porcelain	Tod 1977:15
1901	Insulating bushing on knobs	Tod 1977:156
1902	Reversible split-knob	Tod 1977:134
1907	Cleat for corner edges	Tod 1977:128
1910	End of porcelain cleats boom era	Tod 1977:14
1932	End of knob and tube boom era	Tod 1977:9

The patents themselves can, of course, also be searched directly, a task that has been made incomparably easier with the advent of internet-based patent searching (insulator patents are compiled at <http://reference.insulators.info/patents>, and all patents are available at <http://www.google.com/patents> and <http://www.uspto.gov>). Some of the variants of the standard porcelain knob accessible through patent records, for example, are the split knob (1884) and the reversible split knob (1902); and variants of the porcelain cleat include the one-piece cleat (1883), the multipiece cleat (1885), the reversible wire cleat (1891), and the two-wire cleat (1892). For some examples see Figures 7–8 and Table 2, which compile some of the milestones of diagnostic traits of electrical porcelain useful to the archaeologist.

Patent dates should be used with caution. Without a second source of evidence (in other words, if relying on a patent alone), it is always an open question whether the date of patenting is close to the date a product actually reached the market. Many patents were never realized in products, or their releases were delayed. As with all artifacts encountered, time lags between design, manufacture, commercial availability, in-context use, and discard must always be considered.

Porcelain Insulator Markings

For insulators that do not have markings of any kind on them, identifying the style as described above will usually be the only way that approximate dates of manufacture can be obtained. Many insulators, however, do have stamped markings on them, and these markings, when present, are invaluable for dating. Note, though, that markings found on insulators are not always makers' marks: a marking might refer to an item's catalog number, size, patent number, or patent date.

As with the insulator styles discussed above, the reader is again referred to the exhaustive cataloging work done by collectors—in particular, Tod's 1977 work, which lists over 400 electrical porcelain makers' marks (Figure 13), and the website maintained by Elton Gish cited above. Up to three separate sections of Tod's book might be needed to find the dates of a particular marking: the listing of manufacturers and their dates of operation, pages 69–101; the listing of stamped marks and the names of their associated manufacturers, pages 103–115; and the listing of manufacturers' trademarks, pages 168–169.

Conclusion

While this article seeks to provide an introduction, aimed at archaeologists, to the social and material aspects of the early electrification of the American household, it is not intended to provide exhaustive coverage of all artifacts related to electrification, or even of a single class of artifacts within this grouping. This discussion of electrical porcelain used in the wiring of buildings is only introductory; and many other artifacts are worthy of exploration beyond the scope of this article, including glass insulators, light bulbs, fuses, wire, plugs and receptacles, junction boxes, personal generators, batteries, and home appliances. Preliminary research suggests, perhaps surprisingly, that each of these other classes of artifacts is a large topic that warrants a topic-specific article.

Electrical artifacts in late-19th- and early-20th-century contexts are evidence of a period of rapid technical and social change related to the electrification of America. Research suggests that these electrical artifacts will, in many cases, be useful for dating sites and contexts. Archaeologists are encountering these artifacts in excavations but have not always seen their potential for contributing to dating and interpretation. This, together with a paucity of writing on the topic directed at archaeologists, is perhaps why few archaeological reports discuss electrical artifacts more than cursorily. In the case of household electrical porcelain, the class of artifacts discussed in this article, the potential for dating comes both from morphology, since this is often documented through patents, product catalogs, and other records, and through the makers' marks, many of which have been painstakingly cataloged by collectors.

ACKNOWLEDGMENTS

This article draws on previous research by avocational insulator enthusiasts and, in particular, the extensive work of Elton Gish and Jack Tod. The content was much improved thanks to close readings provided by Elton Gish, Michael Schiffer, Barbara Voss, Larry McKee, Kathy LaVergne, and Erica Gibson. For bringing sources to my attention, thanks are due to Carol Serr, Jakob Crockett, and Liz Clevenger. The idea for this article came about as I was working on excavations at the Stanford University men's gymnasium ruin (Cain et al. 2009), and a special thanks is owed to Laura Jones both for inviting me to work on that project and for obliging my side interest in electrical artifacts while on the clock.

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