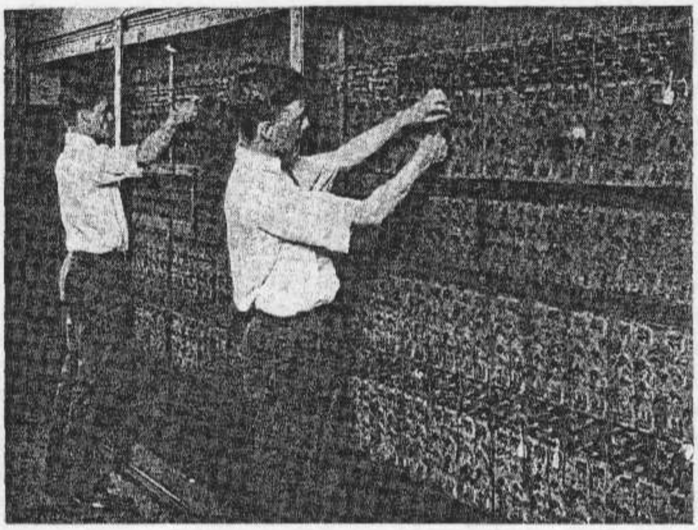
An Artificial Line, or Technology as Spectrology: Governing Circuit Profit and Surplus

In 1859, 28-year-old Samuel Alfred Varley (1832-1921) returned home to London after serving in the Crimea as superintendent of the "first field telegraphs ever used in warfare." He had supervised the laying of the Varna-Constantinople cable, the longest underwater cable to date. Varley experienced combat more as a technical battle against the limitations of the telegraph than as war against people. Like others who have experienced war firsthand, a specter haunted Varley. A technological specter lured him away from what most of his colleagues considered to be engineering common sense.

Home from the war, Varley prepared a paper for the London Royal Society of Arts (Varley 1959). According to Lt. Col. A. G. Lee, who wrote about Varley in a 1932 article, he retired to his study to sit "deep in thought for hours. ... For weeks beforehand, [Varley] committed what was to him the extravagance of riding in cabs when travelling on business, so as to be able to ponder over his problems undisturbed." Finally, he committed his ideas to paper, but not until the day before the Royal Society meeting (Lee 1932, 962-3). There Varley introduced the artificial line, "a device," wrote Paul C. Hoernel in the 1925 inaugural issue of the *Bell Laboratories Record*, "not widely known but of increasing importance throughout the entire history of electrical communication" (Hoernel 1925, 51).



Paul C. Hoernel featured this illustration of two Bell Lab employees, W. G. Breivogel and C. B. Northrup, setting up an artificial line of telephony. As he put it, "by proper connections of the equipment a great variety of actual lines may be simulated" (1925, p. 57).

Following the introduction of Varley's artificial line as a way of computing the electrical properties of real circuits came the struggle to introduce it as a regulator of duplex telegraphs. Duplexing allowed telegraphers to double line capacity inexpensively. However, each new duplexing technique went against prevailing engineering common sense. Before telegraphers became habituated to it, they thought of it as unnatural. Bernard Finn has shown that the introduction of more profitable telegraph circuits in the 1870s evinced typical "growing pains,... [a] classic pattern of stubborn resistance to reluctant acceptance to even enthusiastic support" (Finn 1976, 1292). James Brittain noted that in 1899, when George Campbell proposed real circuits that could be regulated to work like artificial telephone lines, his contemporaries initially were uneasy about his "deceptively simple" proposal (Brittain 1970, 36).

Engineers commonly called duplexed telephone circuits "phantom circuits" or simply "phantoms." They formed "superphantoms" by following the same principle *ad infinitum*. D. G. Tucker has followed the history of phantoms from their invention in the early 1880s to their practical application with the development of suitable transformers around 1900, to their eventual application to loaded open lines and cables around 1910. "The name 'phantom,'" suggested Tucker, "although picturesque and of obvious attraction (hence its dominance), was much less accurate than the earlier terms, 'superposed,' 'superimposed and 'derived' circuit, all of which correctly described the arrangement" (Tucker 1979, 893). If Wittgenstein was right about how people use language, the common language of engineering, just like all common language, accurately characterized the situation. There was something ghostly about "phantom" circuits.

I suggest that we think of the artificial line as an electric regulator, an electrical analog to the steam-engine governor (mechanical regulator) and a forerunner of the negative-feedback amplifier (electronic regulator). This perspective provides us with an historical pattern by which to contextualize the initial perception of Harold Black's 1927 negative-feedback amplifier as something that "first appeared to many to violate common sense" (Brittain 1977, 342). Hendrik Bode sounded "decidedly pessimistic" in admitting in 1940 that the engineer of electronic regulation "must be a creature of mixed emotions" (Mindell 2000, 430). What else other than a phantom had Bode in mind when he spoke of technical *self*-regulation (a feedback amplifier)—*not* regulation itself—as something which "is always just around the corner"? For more than a half-century, then, a technological specter haunted the evolution of the communication network: the phantom of technical self-regulation. To link the ideology of technical self-regulation to the history of the political economy of the devaluation of the (social and natural) labor power of regulation, and to link circuit profit (gain) to circuit surplus (loss), we will do well to return to London in 1859 and

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a different specter.

Evidently, circuit phantoms troubled another London inhabitant, the exiled German Karl Marx. Both Jacques Derrida (1994) and Louis Althusser contend that a specter haunted Marx until he produced the concept of surplus value. In 1859, as Varley argued for matching the real circuit to that of the artificial circuit, Marx argued for the mismatch between the apparent evolutionary unfolding of the artificial circuit of capital and real historical struggles (Althusser and Balibar 1979, 168). By the 1860s and 1870s, as Varley's artificial lines came into use, Marx had named his circuit specter (the specter of the circuit of capital) by translating "the *language* of this predecessor in an immediate substitutional reading," and by pronouncing the words "*surplus-value* where Ricardo had pronounced the word *profit* — or the words *relations of production* where Ricardo had pronounced the words *distribution of income*" (Althusser and Balibar 1979, 168).

Surplus value "is not a measurable reality," but "the concept of a relationship, the concept of an existing social structure of production, of an existence visible and measurable *only in its effects*" (Althusser and Balibar 1979, 180). I think that this is what engineers talked about when they spoke about "phantom circuits." They could see and measure their effects, but not the circuits themselves. The term "surplus-value" has such importance, Althusser explained, because "it directly affects the structure of the object whose future is at stake in the simple act of naming" (Althusser and Balibar, 146). The concept of surplus value points to the determination of the circuit of capital by a historical struggle over surplus-value production, not by liberal market exchange. Historiographically, the term freed history from the Hegelian evolutionist unfolding of history towards a society like that of classical political economy, that is, it freed historical interpretation from the specter of evolutionism. The philosophical defense of the circuit of classical political economy as technically superior turned real history into a specter of ideal evolution. The concept of surplus value pointed at what haunted the profit of the circuit of capital by suggesting that what was presented as an inevitable private profit was, relatively, a contested public loss. I import this concept from intellectual to technical history in order to interpret what was haunting the profit of a circuit containing an artificial line (and regulators in general).

In its embryonic form, Hoernel has argued, the artificial line was a regulating (balancing) resistance (drawing, Hoernel 1925, 52). The artificial line, formed by an act of branching the sending current, had a resistance equal to the real line. Value was extracted as a surplus by doubling the resistance of the circuit and by sending current to the ground. The profit from adding an artificial line arose because the process of sending signals could no longer be interrupted by the reception of incoming signals. If a signal went out when no signals were being received, the signal that traversed the artificial line went to the ground. Incoming signals could be received at some point in the artificial line, while signals could still be transmitted.

In the event that a signal was coming in while a signal was going out, the current of the outgoing signal, after traversing the artificial line, became equal in strength to the incoming signal. It would return to the outgoing circuit and cancel the incoming signal, because the two were equal. They were of equal strength and had traversed an equal resistance. As a result, the outgoing signal current was the only one to leave the sending apparatus. In other words, the artificial line allowed for the simultaneous sending and receiving of signals. In the hopeful event of full operation at both ends of the telegraph line, this arrangement could double the carrying capacity of an existing telegraph line without a need to build a new line. Today, we would also say that the artificial line could make telegraphy interactive, because the two ends could send signals simultaneously.

Obviously, such circuits increased the productive capacity of telegraph lines, which, in turn, required an increase in consumption. If the assumption of surplus value extraction was successfully hidden (and it *was* successfully hidden), a technical imperative of production appeared to self-regulate the production-consumption (exchange) relationship. One who cannot see the structure of accumulated surplus (required to start such processes, and, also, reproduced in an expanded scale by such processes) is prepared to interpret the history of capitalist regulation as embodying liberal substitution of equals (exchange), i.e., as technical self-regulation. By contrast, the concept of surplus value, freed of the Hegelian teleology of self-governed (Smithian) liberal change, points to the reality of governance by capitalist production, not to the ideology of self-

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What is an Artificial Line Circuit?

An artificial line circuit was an analog of a real line with respect to its electrical characteristics (resistance, inductance, and capacitance). It could work as a regulator (on line) or as a computer (off line). The quality of its construction and the choice of the way it connected to a real line determined the degree of approximation to a real line. The extent of that approximation, in turn, determined the success of regulation or computation. In computing, an artificial line connected to a real line via a mental circuit consisting of a mathematical table, a graph, or a function. In regulating, it connected via an actual circuit in an arrangement that we would now call "negative feedback." The feedback was that part of the real circuit's outgoing flow that returned as an incoming flow after traversing the circuit of the artificial line. It was a negative feedback because the purpose of the feedback was to negate whatever part of the incoming flow ought not to be transmitted. We then can call the artificial line an electrical regulator of an electric circuit that functioned similarly to the steam-engine governor — a mechanical regulator of a mechanical circuit, and to the negative-feedback amplifier — an electronic regulator of an electronic circuit. In this sense, the artificial line can be considered as an example of a regulator of the electrical era. The accompanying essay describes the early stages of the artificial line circuit in which it worked as a regulator rather than as a computer.

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governance by market exchange. Governors (mechanical, electrical, and electronic) have been fetishized as technical self-regulation (automation), whereas they were typical of the inherent tendency to increase the value required for regulation.

My research on the use of the artificial line to compute power transmission suggests that, as MIT President Dugald Jackson explained in 1923, the history of the artificial line was a history of a "struggle" (Dellengaugh 1923, 821). For example, when electrical engineers at Union College constructed an artificial line designed by a team lead by famed electrical engineer Charles Steinmetz, they discovered that the computing units mysteriously would break. Arthur Kennelly, the leading expert then on artificial power transmission lines, explained that skill was required even when laboring to connect an artificial line (Kennelly 1928, 221-222). Appearances aside, computing connections always required considerable skill and labor. The two men pictured laboring with the computing connections of an artificial line in the *Bell Laboratories Record* 1925 article (picture, from Hoernel 1925, 57) remind us of the labor to produce the ENIAC computing connections. Between the artificial line of the 1920s and the electronic computer of the 1940s, the increase of this labor resulted in the extensive incorporation of women workers into the computing labor force.

In my opinion, it was the strong intervention of government, not the weak intervention of a technical governor, that ultimately could regulate so as to avoid the irregularities arising from what capitalist production could not compute. Fordism offers the standard historical example of how an increase in productivity could not be uncoupled by an associated decrease in flexibility: the technical production imperative appeared to match naturally to consumption only until the regulation of consumption became socially impossible, and an iron regulatory state had to intervene. Bode was no less pessimistic than the typical American during the Great Depression, the era when Fordist production produced massive social suffering. Enter the suffering of nature. A century ago, one could emphasize only the externalization of the increased private cost of regulation to public social labor by focusing on the conditions of the global working class as a proof of a social disaster and as the specter haunting the circuit of capital. We now know that the cost of regulation also could be externalized to the public labors of nature, for we now know that an ecological disaster is also just around the corner.

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Vogue Picture Records

In May and June, 2000, the Davidson library at the University of California, Santa Barbara, exhibited its outstanding collection of Vogue Records' "picture discs" produced after 1946. Picture disks, introduced as early as the 1930s, were an attempt to enhance the appeal of ordinary phonograph records by including artwork on the disc, a precursor to the more elaborate artwork associated with the long-playing record album.

The Vogue Records label was established to commercialize picture discs made by a process developed by Sav-Way Industries of Detroit. The process involved sandwiching a structural aluminum disk and paper artwork between layers of vinyl, into which the recording was pressed. While difficult to manufacture, the disks were apparently of high quality, with less surface noise than ordinary records. The appeal of the artwork, which consisted of sentimental, full-color airbrushed images resembling advertisements, was unfortunately offset by the cost of the records, at least two to three times the cost of an ordinary record. After only a year, Vogue was liquidated, and today the 67 known Vogue titles are prized collectors items. The Vogue records are an outstanding example of the grafting of visual entertainment onto a medium designed to carry aural information.

- UC Santa Barbara Vogue Records exhibit companion site: <www.library.ucsb.edu/speccoll/pa/vogue.html>
- Association of Vogue Picture Record Collectors site: <www.voguepicturerecords.org.records.html>