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2/2020_text

Wolfgang Schivelbusch_ World Machines. The Steam Engine, the Railway, and the Computer

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Preface to the 2014 Edition

World Machines: The Steam Engine, the Railway, and the Computer

When this book was first published, in 1979, the personal computer was barely known and the Internet not dreamed of.

The following thirty years brought the Digital Revolution, an event often compared in scale and impact to the Industrial Revolution of the nineteenth century.

Could it be that the railway, the accelerator of the Industrial Revolution, and the computer occupy different points along/on the same trajectory of machine evolution?

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When, in the early 1970s, after having completed my PhD with a dissertation on Post-Brechtian East German drama, instead of continuing the study of literature I switched to the subject matter of railways, none of my late Frankfurt School and early post-structuralist friends showed any interest. They jovially derided my perceived interest in choo-choo trains bestowing me with gifts like railroad engineers' caps and station masters' whistles.

Their concern with things technical and material was limited to Adorno and Horkheimer's concept of the culture industry and to texts like Walter Benjamin's *The Work of Art in the Age of Its Technical Reproducibility.*

There was, to be sure, Norbert Elias's *The Civilizing Process*, a rediscovery from the Weimar period, causing a certain delight. Understanding concrete objects such as the fork and the handkerchief as subjects of history was welcomed as an antidote to the thin air of Adornian and Habermasian texts. But that was about how far it went.

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I shared this world view until the summer of 1970, when, before embarking on my dissertation, I first visited America.

The trip was intended as an escape from the ennui following the excitement of the Berlin years of 1967 to 1969.

To the romantic neophyte of Karl Marx, the election of Richard Nixon seemed like a modern replay of the Eighteenth Brumaire of Louis Napoleon.

In terms of more recent history, the America of the Vietnam War, the ghetto riots, the Democratic convention in Chicago, and Nixon's election suggested a repeat of the last throes of the Weimar Republic on a larger scale.

Having by late birth missed the latter, I now hoped to occupy a ringside seat and watch the Götterdämmerung of the American republic.

It did not happen in the summer of 1970, nor in the following decades.

Every educated European fascinated by the American experience attempts to become a little Tocqueville. I was no exception.

The discovery that America's exceptionalism/*Sonderweg* had a lot to do with the American way of technology came fast. Leo Marx's classic *The Machine in the Garden* helped, in tandem with Siegfried Giedion's *Mechanization Takes Command.* An important moment was the discovery, in a standard history of technology in America, of the peculiar American ax. Its evolution from its European cousin through two centuries of American tree felling perfectly illustrated one of my favorite Marxian concepts: the metabolic exchange between Human and Nature, or more precisely, the different ways this metabolism worked in Europe and in America.

From the ax to the railway was but a step.

My original idea was to understand America by studying the different paths of European and American railway technology, railway design, railway psychology.

In the writing, the perspective broadened. The European-American comparative perspective was reduced to one chapter.

Thus *The Railway Journey* became my journey into the industrialization of space, time, and mind in the nineteenth century.

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Opening *The Railway Journey* with a historical sketch of the steam engine's technical evolution, I followed an established pattern.

Every history of the nineteenth century presents it as the central character—a kind of technological Napoleon—in the epic of early industrialization.

Following this convention, I reaffirmed how the decisive step had been the translation of the alternate up-and-down—or oscillating—movement of the steam-driven piston into the circular motion of the driving wheel. According to received wisdom, without this transformation there would have been no locomotion, no railway, no Industrial Revolution.

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It took me forty years and the Digital Revolution to realize that I had missed the more important point of the invention preceding it.

This invention was, of course, placing a piston in a cylinder and applying the pressure of steam.

The resulting up-and-down (or forth-and-back, or oscillating) motion became humankind's first artificially produced mechanical movement.

The analogy between the steam engine and the firearm was a later conclusion. For could the gun's barrel not be seen as a *cylinder* projecting its missile piston forward, and the steam cylinder as a reciprocating gun? In other words, were both not machines producing power out of nowhere, and did they both not revolutionize their centuries—the fifteenth and the nineteenth—respectively?

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Before the invention of the piston-cylinder-steam ensemble, motion had to be removed, or *borrowed*, from an external natural source (wind, water, animal) and transferred *to* the tool or machine or vehicle in question. This analogue transfer took place in a one-to-one ratio. No waterwheel was able to outrun the stream driving it, no sailing vessel could outspeed the wind, no coach could top the velocity of the horses pulling it.

By no longer receiving its motion from an external source but somehow creating it within itself, the steam engine seemed to be the mechanical equivalent of the Copernican revolution.

In chemical fact, of course, it did not *create* power but took it out of nature as well, just as all previous forms of locomotion had. The difference was that it did not transfer an existing form but forced a new form of power out of combustible matter.

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Oscillating motion in itself was obviously nothing new, let alone revolutionary.

Any blacksmith using his hammer practiced it.

The revolution of the steam-driven piston was that its oscillating stroke was a type of motion not found anywhere else in nature. This stroke was a mechanical building block, or more precisely: it was the mechanical equivalent of a binary action. Or even more precisely: the piston's up-and-down movement was no longer the analogue of any form of movement found in nature but possessed a *binary-digital* logic all its own.

The device that enabled the steam engine to automatically *reverse* the piston's course and at the same time change it into rotating motion was the crankshaft.

According to the laws of mechanics and kinetics, to reverse a movement, it must first be brought to a halt and then set in motion again. The crankshaft manages to do both in a continuous motion and with unheard-of velocity. For the nonengineer, this borders on the miraculous. As do the digital switches in the computer.

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We can understand the motion that the steam engine produces as a kind of atom or molecule of motion. As with the smallest particles of matter, those of motion can be reproduced/repeated in quantities as inexhaustible as the supply of fuel and of water. That supply at the time of the invention of the steam engine was seen to be as infinite as today's supply of silicon for computer processors.

Building blocks—as the literal brick in the wall, Lucretius's atoms, and today's digital bits—are particles whose sole function is to constitute a minuscule part of a whole. Uniformity and limitless quantity are their characteristics.

The old atomistic question regarding the whole and its parts remains. It can—or must?—now be applied to the digital: how does the heterogeneity of the things that constitute the world evolve from a pool of identical particles?

That we still experience the difference between the machine-made and the handmade as strongly as ever seems to reveal an almost instinctual human disposition to cling to—and communicate with—the non-machine-made. Fascination with ever-smarter machines alternates with repulsion. The disgust, described by Kant, of the man who enjoys the nightingale's song, only to discover that it was a mechanical imitation, recurs whenever we feel—and are—deprived of the original by the reproduction.

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At this point it is important to remember that the original—preindustrial—meaning of *machine* was not the technical contraption but the effect of being tricked or cheated, as the word *machination* and the term *deus ex machina* suggest.

At the high point of nineteenth-century industrial culture, Franz Reuleaux, the great theorist of machinery, caught the double-crossing nature of the machine when he defined it as the merciless transformer of 'the cosmical freedom of natural forces' into the 'order and law which no ordinary external force can shake'.[1] This was the full-circle return to the early modern view of the world as the world machine. The machine's promise was not only to duplicate and imitate nature but to multiply her efficiency.

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Once we accept that every new technology is an attempt to submit nature to its rules, that the physical means to achieve this is the machine, and that the resulting new reality is a machination, doppelgänger, or alias of nature, we have to conclude that each time this happens the world becomes a world machine.

1. Franz Reuleaux, *The Kinematics of Machinery,* tr. and ed. Alex B. W. Kennedy (London, 1876), p. 34.

It does not matter whether the new technology is immaterial or material, whether it is script, print, money, mechanical clocks, firearms, steam engines, or computers.

This accepted, it is easy to see what the railway of the nineteenth century and the computer of the present have in common. Both are attempts to re-create and reproduce the world in their image. Both succeed. And they succeed through their *machinations.* Whether the world they create is the global web of steam-powered industrial production and transportation or the digitalized cyberworld of information, it is *their* world machine.

Let them derail, explode, crash, or simply pull the plug, and both world machines come to an immediate halt.

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In his classic *On the Economy of Machinery and Manufactures* (1832), Charles Babbage speaks of a machine able to precisely count the strokes of the piston in a steam engine's cylinder. Babbage knew what he was talking about. Before he became the famous mathematician and constructor of the first calculating machines, he had worked as a *computer.* A computer in the 1830s was not a machine but a person employed for the sole purpose of producing mathematical tables required for calculating vast amounts of numbers in the fields of astronomy, navigation, and industrial machinery. In other words, a computer was a worker who instead of serving an industrial machine with his hands served the task of calculation with his brain. What connected both kinds of work was, as Babbage later put it, their 'intolerable labour and fatiguing monotony'.[2] He became the first to think of a machine to execute this kind of mechanical calculating labor. His often quoted exclamation 'I wish to God these calculations had been executed by steam!' and his wishful vision that 'it would be extremely convenient if a steam engine could be contrived to execute calculations for us' are proof of the contemporary belief in the omnipotence of steam, whether factory or railway applied.[3] As the steam engine was able to perform physical work endlessly without fatigue, so Babbage imagined a steam-

2. *The Works of Charles Babbage,* ed. Martin Campbell-Kelly (New York, 1989), vol. 2, p. 6.
3. 'The Science of Number Reduced to Mechanism', in *The Works of Charles Babbage,* ed. Martin Campbell-Kelly (New York, 1989), vol. 2, p. 15.

driven mechanical brain calculating without ever getting bored or fatigued.

In a similar vein, Ada Lovelace (daughter of Byron), Babbage's collaborator on his next machine project, suggested programming the Analytical Engine with punched cards, following the model of the mechanical loom constructed by the French inventor Jacquard: 'The Analytical Engine weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves'.[4]

William Whewell, a philosopher of science and a contemporary of both, compared the calculating machine with a railway, on which 'we are carried along . . . entering it at one station, and coming out of it at another'.[5]

Compare this to Heinrich Heine's image in 1842 of the railway bringing the surf of the North Sea right to his doorstep in Paris, and to the various accounts of early twentieth-century Ford factories, according to which raw materials such as iron and rubber entered the assembly line at one point and reappeared at the end as the finished Model T automobile.

In short, steam-driven machinery, whether applied in industry, transportation, or calculation, seemed to miraculously annihilate the toil formerly associated with any kind of production.

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Babbage and other highbrow advocates of the Industrial Revolution were in their time labeled *intellectual industrialists* because they believed in the universality of the principles of mechanization, whether material or immaterial.

Multiplying the production of commodities and multiplying the capacity of the mind through mechanization are obviously two different things, involving different consequences.

The former has been around for some time now and led to what is known as consumerism.

Although the latter is a more recent reality, Babbage glimpsed its potential.

4. Ada Lovelace, note G to L. F. Menabrea, *Memoir on the Analytical Engine,* ed. Lovelace (1843).
5. William Whewell, *Of a Liberal Education in General, and with Particular Reference to the Leading Studies of the University of Cambridge* (London, 1850), p. 41, quoted in Simon Schaffer, 'Babbage's Intelligence: Calculating Engines and the Factory System', *Critical Inquiry,* vol. 21 (1994), p. 225.

What has been called his 'fantasy of mechanically amplified intelligence', able to produce a 'divine archive of matter and spirit, extending down to the most basic molecular level', marks the crossing of two lines.[6]

The first line is the utopian desire of mathematics to reproduce the real world in numbers, as stated in Pierre-Simon Laplace's *A Philosophical Essay on Probabilities,* better known as Laplace's demon: 'An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greater bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain, and the future just like the past would be present before its eyes'.[7]

The second line is the production of the real computing power needed to achieve this.

Here the aim is to not just to record the world in numbers but to make a numerical alias of it, which subsequently can be reconstituted/recomputed at one's leisure. No previous world machine has been able to do this.

In the following passage written by Babbage in 1837, from a chapter titled 'On the Permanent Impressions of Our Words and Actions on the Globe We Inhabit', we need only replace his term 'a Being' (i.e., God) with the present day's megacomputing agencies such as Google and the NSA to realize that the digital reproduction of the world has penetrated to its very molecular level: 'Every atom, impressed with good and with ill, retains at once the motions which philosophers and sages have imparted to it, mixed and combined in ten thousand ways with all that is worthless and base. The air itself is one vast library, on whose pages are forever written all that man has ever said or woman whispered. There, in their mutable but unerring characters, mixed with the earliest, as well with the latest sighs of mortality, stand forever recorded, vows unredeemed, promises unfulfilled,

6. Tamara Ketabgian, 'Prosthetic Divinity: Babbage's Engine, Spiritual Intelligence, and the Senses', *Victorian Review,* vol. 35, no. 2, p. 35.
7. Pierre-Simon Laplace, *A Philosophical Essay on Probabilities,* tr. Frederick Wilson Truscott and Frederick Lincoln Emory (New York, 1902), p. 4.

perpetuating in the united movements of each particle, the testimony of man's changeful will'.[8]

When around the same time the two German émigré authors of the *Communist Manifesto* wrote that the bourgeoisie was recreating the world *in its own image,* their biblical language may have prevented them from realizing that even this image was about to lose its ownness to the machine.

8. 'The Ninth Bridgewater Treatise', in *The Works of Charles Babbage,* ed. Martin Campbell-Kelly (New York, 1989), vol. 9, p. 36.