Industrial Transistions: A visual study of technological evolution

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November 13, 2003

1 Introduction

Curiosity and ingenuity represent humankind's most valuable attributes; they spawn our great inventions and make possible our current technological society. Humankind has come to rely on tools and machines in virtually every aspect of life. Although historians may group technological evolution differently, no historical framework can ignore the predominant theme of human divergence from nature and organic values while simultaneously converging with the machine. In his novel Technics and Civilization, Lewis Mumford categorizes technology's social implications into three distinct technological periods based upon differences in geography, resource and raw materials, energy usage and generation, modes of production and worker type. These groups consist of the eotechnic, the paleotechnic and the neotechnic phases. It is our purpose in this essay to delineate the evolution of energy, transportation, industry and commerce, and society through the three technical phases via photos from the United Kingdom and Iceland.

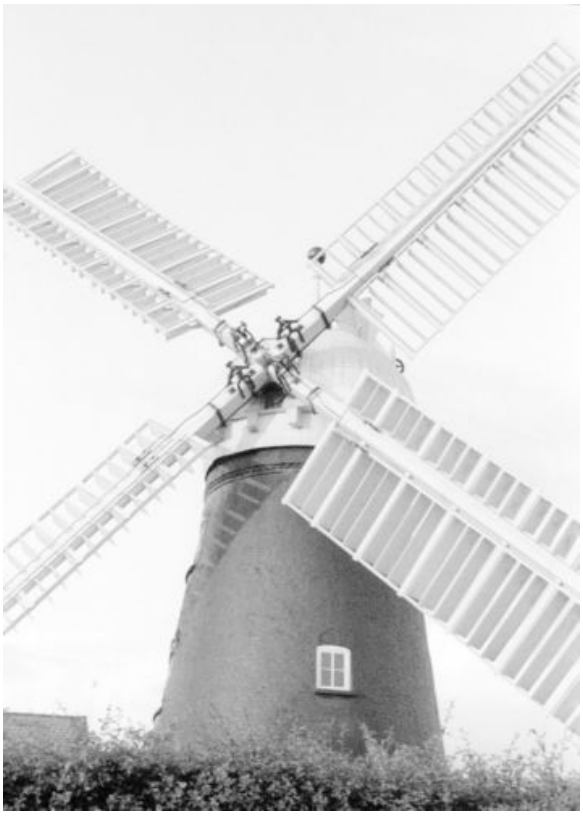

Figure 1: Lincoln windmill. Photo by M. Pickett, May 2003.

2 Energy

2.1 Eotechnic

"*When their living became easy, people did not go in for abstract acquisition: they worked less.*"
- Lewis Mumford

Eotechnic industry was a relatively small-scale operation: people often worked close to the land harnessing wind, water, wood or horsepower. Windmills,

Figure 2: Eling Tide Mill. Photo by M. Narkiewicz, May 2003.

Figure 3: Ponies in Dartmoor. Photo by M. Narkiewicz, May 2003.

like that in Lincoln, England in Figure (1), harnessed the energy of wind. River and tide mills harnessed the potential energy of water. Figure (2) shows the reservoir side of the Eling Tide Mill in Hampshire, England. A tide mill has existed in this location for over 900 years. Until the 19th century all the gears were made of wood. It operates almost like a river mill, except it differs where the pond is made. As high tide recedes, it closes a valve-like gate and thereby retains water upstream of the gate in a millpond with high-tide water depth. Water from the millpond is then released in a controlled manner, hits and spins the waterwheel, and causes the millstones to grind wheat into wholemeal flour. While a river mill can only operate seasonally, a tide mill can operate year round in two 5 hour shifts per day, (Eling, 2000). Ponies grazing in Dartmoor National Park, depicted in Figure (3), symbolize the Eotechnic reliance on animals for power and production.

2.2 Paleotechnic

"*Air and sunlight, because of their deplorable lack of value in exchange, had no reality at all.*"
-Lewis Mumford

The Paleotechnic phase harnessed coal energy to make its distinguishing material: iron. Wood and water power of the eotechnic phase was transformed into coal and steam power of the paleotechnic phase. More stress was placed on economics in the Paleotechnic since its energy sources, coal and steam, were not free like wind and water. The steam driven beam engine in Camborne, Cornwall represents paleotechnic improvement to mine labor efficiency and safety. See Figure (4). Beam engines draw water from mines and lower buckets (kibble, skip, and gig chronologically) into the mine. This engine is driven by steam in a boiler below the chamber. The outer cylinder kept the inner cylinder very hot thus making it more efficient than other engines of its time.

The large factory building and tall stacks shown in Figure (5) remain from what is assumed to be an old coal plant in Blyth, Northumberland. Its importance lies in the fact that it is abandoned. The decline

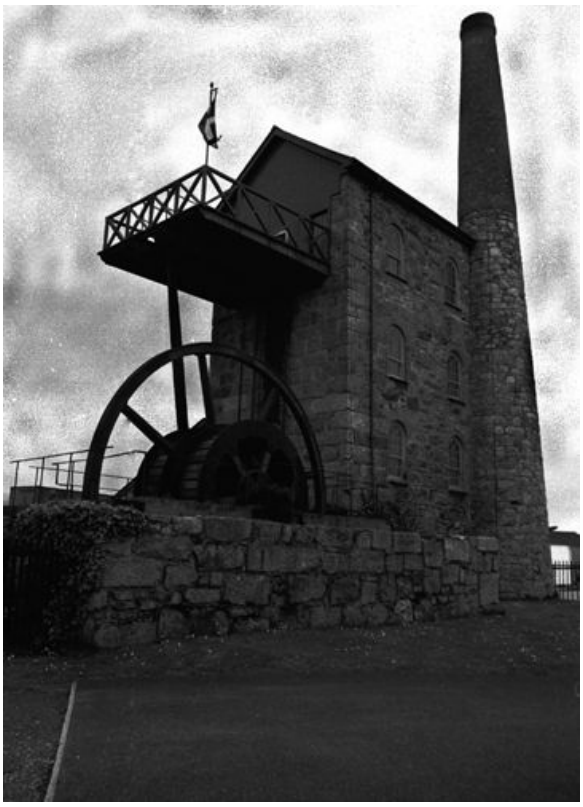

Figure 4: Camborne Steam Engine. Photo by M. Narkiewicz, May 2003.

Figure 5: Abandoned power plant. Photo by M. Pickett, May 2003.

Figure 6: Small wind farm in southern England. Photo by M. Pickett, May 2003.

Figure 7: Fred Treble's photovoltaic array. Photo by M. Narkiewicz, May 2003.

of the coal industry in the UK emphasizes the need for renewable energy sources to dominate our energy production. Mumford warns, "the damage to form and civilization through the prevalence of these new habits of disorderly exploitation and wasteful expenditure remained [in the neotechnic], whether or not the source of energy itself disappeared" (Mumford, 1934).

2.3 Neotechnic

"*Bigger no longer automatically means better: flexibility of the power unit, closer adaptation of means*

Figure 8: Geothermal power plant in Njardvik, Iceland. Photo by M. Narkiewicz, May 2003.

Figure 9: Hot Dry Rock Project, Rosemanowes, Cornwall. Photo by M. Narkiewicz, May 2003.

to ends, nicer timing of operations, are the new marks of efficient industry."
-Lewis Mumford (226).

Neotechnic energy, namely electricity, is so familiar to this audience that it hardly needs description. Some interesting renewable means of electricity generation include windmills, photovoltaic cells, and geothermal wells. Modern windmills differ from eotechnic windmills in that they generate electricity rather than turn millstones. One example of modern windmills is a small wind farm in southern England as seen in Figure (6). Photovoltaic (PV) solar panels can be used on most building surfaces and roofs, like the roof of Fred Treble's house in Farnborough, England. See Figure (7). If just 10% of roofs in the UK were covered with PV cells, they would generate 7.3% of the total energy consumption. PV cells are actually cheaper than diesel fuel (Treble).

Iceland, advantageously located above the Mid-Atlantic Rift, has an abundance of geothermally heated water, which is an economically viable heat source. Figure (8) portrays the inside of a geothermal power plant in Njardvik. In 1971 and 1972, two holes were drilled into the peninsula: each contained 2/3 the level of salinity of the ocean and were 242° C. In Iceland, 90% of all homes are heated by geothermal heat and the generating capacity of the plant is about 140 MW of hot water and 45 MW of electricity. Geothermal heat, however, is less readily accessible in England than in Iceland. Instead of collecting natural steam, the Hot Dry Rock (HDR) experimental site in Rosemanowes, Cornwall pumped water into hot rocks through injection wells, allowing the water to become heated through the joints in the rocks, and returned the heated water to production wells at the Earth's surface. A power plant, connected to the injection wells underground, converted heat into electricity. The Hot Dry Rock project, as seen in Figure (9), operated from 1977-1991 and reflects the Neotechnic movement away from controlling nature towards utilization of nature (Hot Dry Rock).

Figure 10: Oil can at Eling Tide Mill. Photo by M. Narkiewicz, May 2003.

Figure 11: Fishing port in Mousehole, Cornwall. Photo by K. Johnson, May 2003.

3 Industry and Commerce

3.1 Eotechnic

The Eotechnic growth of monetary economies markedly changed commerce. Gutenberg's printing press utilized interchangeable parts, which revolutionized manufacturing and eased the many burdens of self-sustainability. Towns grew around industry and commerce. For example, Eling grew around the tide mill, and Mousehole grew around its fishing port. Figure (10) represents the important link between the Eotechnic, Paleotechnic, and Neotechnic phases: it illustrates the emerging need for oil to lubricate machinery (Paleotechnic) and later to fuel it (Neotech-

Figure 12: Blaenavon iron mine. Photo by M. Narkiewicz, May 2003.

nic). The background of wood symbolizes society's previous reliance on wood for power and as a raw material. Wood provided the technological foundation that Paleotechnic and Neotechnic civilizations rest upon. Although wood is no longer crucial for our energy supply, it can support our future power needs. Figure (11) depicts the southern quay of Mousehole, a fishing town located near Land's End in England's southwestern province of Cornwall. Mousehole was an important fishing port beginning as early as 1266. The local fishing industry, however, has diminished in the last 100 years (Cornwall Online).

3.2 Paleotechnic

"*work was no longer a necessary part of living, it became an all-important end*"
-Lewis Mumford

Paleotechnic industry and commerce are characterized by a change in work ethic. Humans became the producers of the commodity of labor. It was more important to obtain a product than to celebrate the talents of workers. The expansion of industry was due to the fact that energy became mobile: production was no longer confined to areas of wind and water resources. Rather, industry could be located anywhere. New demands and techniques for mining developed. Blaenavon, seen in Figure (12), profited from its mineral resources and represents a range of industry spanning the Eotechnic and Paleotechnic phases. Thought to have been worked since Pre-Roman times, Blaenavon shifted from eotechnic mining of timber and limestone to paleotechnic mining of coal and ironstone (Blaenavon Online).

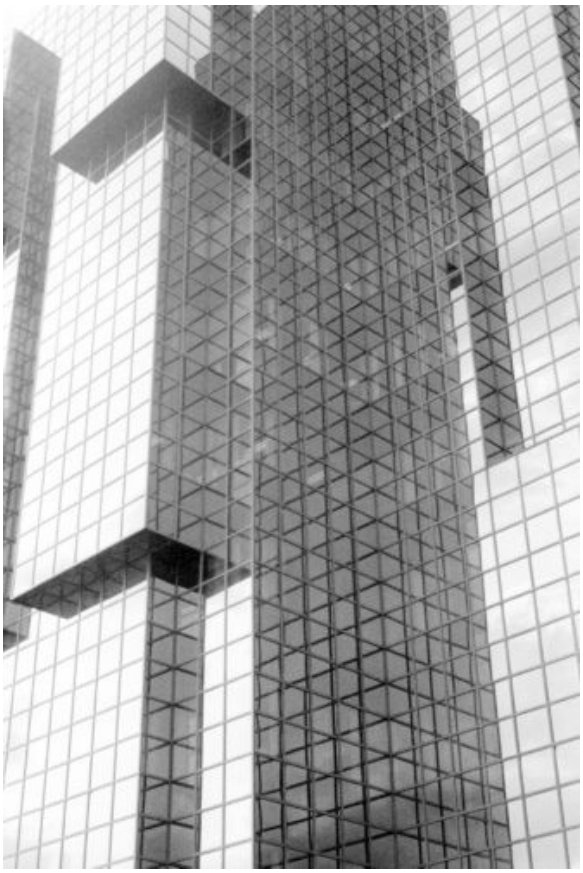

Figure 13: Skyscraper in the financial district of London. Photo by M. Pickett, May 2003.

3.3 Neotechnic

Neotechnic industry and commerce revolves around consumption and economic growth. Skyscrapers in London's financial district, as seen in Figure (13), and small-town shops in the business district of Axminster, as in Figure (14), exemplify Neotechnic com-

Figure 14: Shops in Axminster, Devon. Photo by K. Johnson, May 2003.

Figure 15: Clapper Bridge, Postbridge, Dartmoor, Devon. Photo by M. Pickett, May 2003.

merce. People are centered in cities and use more advanced and efficient technologies, but still commonly abide by distilled paleotechnic values of the economic man.

4 Transportation

4.1 Eotechnic

Eotechnic transportation relied on metabolic (both human and animal) power, water power, wood and stone. Clapper bridges, unique to the Dartmoor area, were largely constructed in the 13th and 14th centuries (Dartmoor Online). Local granite comprises the pillars and large slabs of the Clapper Bridge in Postbridge, Dartmoor, and can be seen in Figure (15). Glimpsed between the pillars of another bridge, the Clapper Bridge in the background of Figure (16) symbolizes the transition from Eo- to Paleotechnic transportation. Wider and sturdier bridges were needed to carry the heavier ore loads that were required for growing paleotechnic industry. The Clapper Bridge inspired its stronger neighbor just as the Eotechnic inspired and enabled the Paleotechnic Phase.

Figure 16: Clapper Bridge, Postbridge, Dartmoor, Devon. Photo by K. Johnson, May 2003.

Figure 17: Engine driving down the road. Photo by M. Narkiewicz, May 2003.

Figure 18: SS Great Britain. Photo by M. Narkiewicz, May 2003.

Figure 19: Iron Bridge. Photo by M. Pickett, May 2003.

4.2 Paleotechnic

Paleotechnic transportation used coal, iron and steam engines. As seen in Figure (17), steam engines were (and are!) used for locomotion. Additionally, the Steamship Great Britain is the world's first and only surviving iron-hulled, screw propeller-driven, steam-powered passenger liner. See Figure (18). Launched in 1843, the ship was two times the tonnage of any previous ship and over 100 ft longer than any previous ship (SS Britain). A discussion of the industrial revolution would be incomplete without Ironbridge, Shropshire: the so-called heart of the Industrial Revolution. Ironbridge, seen in Figure (19) is the home of the world's first cast iron bridge: The Iron Bridge was built over the River Severn at what was formerly 'Coalbrookdale' in 1779. Subsequently, a two-mile stretch along the Ironbridge gorge became an UNESCO World Heritage Site in 1986 because of its influence on coal mining, iron production and its monumental and historic bridge (Ironbridge).

The rise of non-metabolic energy sources and industry during the paleotechnic demanded similar improvements in modes of transportation that the neotechnic phase delivered.

4.3 Neotechnic

Neotechnic transportation relies on rapid movement of people and goods. Although "man on his feet is thermodynamically more efficient than any motor-

Figure 20: Clifton Suspension Bridge, Bristol, UK. Photo by M. Pickett, May 2003.

Figure 21: Automobile. Photo by M. Narkiewicz, May 2003.

Figure 22: St. Michael's Mount, Marazion, Cornwall. Photo by K. Johnson, May 2003.

ized vehicle and most animals," (Illich, 1978), non-metabolically powered vehicles have come to dominate throughout neotechnic societies because of the desire for comfort and economic gain. The Clifton Suspension Bridge of Bristol, England was designed for foot and animal traffic, yet currently "cope[s] with today's vehicles of up to 4 tons in weight," (Clifton). See in Figure (20). Bicycles, automobiles, airplanes, metros, alloy bridges and mechanized locks are examples of neotechnic transportation. The automobile, of Figure (21), is an obvious example of Neotechnic transportation.

5 Society

5.1 Eotechnic

"*The goal of the eotechnic civilization as a whole until it reached the decadence of the eighteenth century was not more power alone but a greater intensification of life: color, perfume, images, music, sexual ecstasy, as well as daring exploits in arms and thought and exploration.*"
-Lewis Mumford

The Eotechnic phase increasingly witnessed the separation of form from function, especially between man and craftsman. "While the tool still dominated production energy and human skill were united

Figure 23: House in Chester, Cheshire. Photo by M. Narkiewicz, May 2003.

within the craftsman himself: with the separation of these two elements the productive process itself tended toward a greater impersonality, and the machine-tool and the machine developed along with the new engines of power" (Mumford, 1934). Eotechnic tools enabled individuals to reduce the amount of time they spent working. As a result, leisure time emerged. Although the scientific method, glass equipment and distribution of information via the printing press promoted intellectual inquiry and the invention of glasses prolonged the duration of that inquiry, the rise and humanization of the machine took its toll on society. This toll increases during subsequent technological phases. Although a wealthy class has always existed, as can be seen from the 11th century St. Michael's Mount in Figure (22), it was initially the exception rather than the rule.

5.2 Paleotechnic

"*While humanly speaking the paleotechnic phase was a disastrous interlude, it helped by its very disorder to intensify the search for order, and by its special forms of brutality to clarify the goals of humane living.*"
-Lewis Mumford

The paleotechnic phase fashioned steam, and iron, and society today would not be the same

Figure 24: Electricity infrastructure is easily ignored by those accustomed to it. Photo by K. Johnson, May 2003.

Figure 25: Transportation infrastructures penetrate the urban residential areas in Mousehole, Cornwall. Photo by K. Johnson, May 2003.

without them; however they were produced at a great cost–man was reduced to a machine that longed for the end of the work day.

Acquiring wealth became the heartbeat of paleotechnic society. Ties to nature, the rise of capitalism, the propagation of economic men, technological progress, industrial expansion and further human divergence from nature resulted. Mumford describes, "These new economic men sacrificed their digestion, the interests of parenthood, their sexual life, their health, most of the normal pleasures and delights of civilized existence to the untrammeled pursuit of power and money," (Mumford, 1934). Economic men built houses like that of Figure (23) in Chester, Cheshire to flaunt their status and lead lives of luxury that only royalty could have expected before the rise of the machine. Economic men installed an infrastructure that allows paleotechnic values to persist in neotechnic society.

5.3 Neotechnic

"*. . . so complete has the victory of the machine been during the last generation that in the periodic exodus from the machine which takes place on holidays in America the would-be exiles excape in motor cars and carry into the wilderness a phonograph of a radio set.*"
-Lewis Mumford

The social revolution necessary to complement the Neotechnic technological revolution is yet to come. A more advanced (i.e. humane and just) society lags behind. Mumford recognized this and believed he was living through the social transition. That was 1934. Many argue that we are still awaiting the transformation to justice and civility. Although electricity infrastructures (Figure (24)) and road networks (Figure (25)) have improved the quality of life for many people, we, as a society, need to acknowledge the consequences of the machine. Illich argues: "Below a threshold of per capita wattage, motors improve the conditions for social progress. Above this threshold, energy grows at the expense of equity. Further energy affluence then means decreased distribution of control over that

energy." Furthermore, he argues that we crossed this threshold once transportation exceeded 15 MPH (Illich, 1978). We need to ask ourselves what Mumford claims the paleotects never pondered: are "labor-saving, money-grubbing, power-acquiring, space-annihilating, thing-producing devices were in fact producing an equivalent expansion and enrichment of life?"