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ENIGMA REBUS

PROLEGOMENA TO AN ARCHÆOLOGY OF ALGORITHMIC ARTEFACTS

1. The Consolation of the House Father

"At first glance it looks like a flat star-shaped spool for thread, and indeed it does seem to have thread wound upon it; to be sure, they are only old, broken-off bits of thread, knotted and tangled together, of the most varied sorts and colours. But it is not only a spool, for a small wooden crossbar sticks out of the middle of the star, and another small rod is joined to that at a right angle. By means of this latter rod on one side and one of the points of the star on the other, the whole thing can stand upright as if on two legs."[1]

With these words, the Czech writer Franz Kafka (1883–1924) describes a mysterious being named Odradek in his short story "The House Father's Concern", written around 1917 and first published in 1919. The strange apparatus moves around autonomously, talks like a child, and occasionally laughs dryly. If this were a report about a robot that operates on a terrain known to it and says "Odradek", "No fixed abode" and "Haha" if spoken to, the text would not be very surprising. A similar anthropoid, "Elektro", was built twenty years later by the Westinghouse Electric

1 Franz Kafka, The Cares of a Family Man, in: *The Complete Stories* (New York, 1971), p. 428. The story "Die Sorge des Hausvaters" was first published in: *Selbstwehr. Unabhängige jüdische Wochenschrift* vol. 13, 51/52 (19 December 1919, Chanukkah Issue). "The House Father's Concern" is a more accurate translation of the title, because the German "Sorge" in its intransitive form rather means to worry and not to care, and "Hausvater" does not necessarily imply that the person is married. He could well be a kind of warden.

Corporation and was exhibited at the 1939 World Fair in New York. It could walk by voice command, talk (it incorporated a 78-rpm record player), smoke cigarettes, blow up balloons, and move its head and arms. Similar statues with less functionality (or "features") were developed by Hero of Alexandria in Ancient Greece, by Al-Jazarí in Upper Mesopotamia at the beginning of the thirteenth century, and subsequently by many others.[2] Odradek is a simpler artefact constructed from fewer components — two — but has in a mysterious way acquired biological properties (cf. Figure 1). Since antiquity mobility has been regarded as the *differentia specifica* of living beings, and the ability to talk and to laugh that of humans: "That man alone is affected by tickling is due firstly to the delicacy of his skin, and secondly to his being the only animal that laughs."[3]

The main property that unites Odradek with the creature possessing language is that he does not serve any purpose, as a tool or instrument. "Now I say that the human being and in general every rational being *exists* as an end in itself, *not merely as a means* to be used by this or that will at its discretion."[4] This state of purposelessness, which was historically often interpreted as freedom, can take different forms. Estragon and Vladimir, the main characters in Samuel Beckett's *Waiting for Godot* (1952), deduce from the fact that they exist, but have nothing to do, that they are waiting, and from waiting that somebody will arrive. The interpretation of the Irish writer's play is offered in the lucid anti-Heideggerian essay "Being without Time" by the German philosopher Günther Anders (a.k.a. Stern).[5] Similarly, it could be conjectured that the little device Odradek has concluded, qua Kant's definition, that because it does not fulfil a function it is a human being and should henceforth walk about, communicate, and laugh occasionally.

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2 Hero Alexandrinus, *The Pneumatics of Hero of Alexandria* [ca. 62], trans. Marie Boas Hall (London, 1971); Ibn ar-Razzáz Al-Jazarí, *The Book of Knowledge of Ingenious Mechanical Devices* [ca. 1206], trans. Donald R. Hill (Dordrecht, 1974); cf. Chris Hables Gray, Steven Mentor, and Heidi J. Figueroa-Sarriera, eds., *The Cyborg Handbook* (London, 1995), p. 89.

3 Aristotle, *On the Parts of Animals*, trans. William Ogle (Oxford, 1882), p. 84.

4 Immanuel Kant, *Groundwork of the Metaphysics of Morals* [1785], trans. Mary Gregor (Cambridge, 1998), p. 37. Also in Kafka's "Penal Colony" a machine plays a central role, and the transformation of an object into some kind of human being, appearing also in "Blumfeld, an Elderly Bachelor", is but one of several metamorphoses transgressing ontological boundaries in his oeuvre. In "The Metamorphosis", a family's son turns into an insect; in "A Report to an Academy" an ape becomes a cultivated subject, etc. The classical model for these is obviously Ovid's *Metamorphoses*.

5 Günther Anders, Sein ohne Zeit. Bemerkungen zu Samuel Becketts Stück "En attendant Godot". *Neue Schweizer Rundschau* 21 (1953/1954): 526–540. Included in: G. Anders, *Die Antiquiertheit des Menschen. Band 1: Über die Seele im Zeitalter der zweiten industriellen Revolution* (Munich, 1956), pp. 213–231. English translation in: Martin Esslin, ed., *Samuel Beckett. A Collection of Critical Essays* (Englewood Cliffs, NJ, 1965), pp. 140–151. Anders studied under Martin Heidegger and was married to Hannah Arendt from 1929 to 1937, after his teacher's love affair with her in 1925/1926.

According to Anders, one characteristic of the parable, the genre to which the small text of Kafka very probably belongs, is poetic inversion. To express that humans sometimes show animal behaviour, it creates the alienation effect ("Verfremdung", in German) of portraying animals as humans by exchanging subject and predicate of the proposition.[6] In the case of Odradek this linguistic technique would result in a statement surpassing Julien de La Mettrie's infamous *L'homme machine*: Human beings are not only machines, but even worse, senseless and absurd apparatuses, because they cannot be used to any end.[7] The specific difference of the *zõon* would no longer be *lógon échon*, but the defect to be unable to serve any purpose. Anders derives an analogue conclusion in his book on Kafka:

"If the human being seems 'inhuman' to us today, it is not because he possessed an 'animal' nature, but because he is pushed back into *object functions*. Therefore, the contemporary poet has to invent fables in which objects appear as living beings to denounce the scandal 'humans are objects'. And Kafka has drawn this consequence."[8]

Similar to Beckett's *clochards*, Odradek does not inhabit a house he could be the father of ("No fixed abode"), serves no particular purpose, and pursues no goal. However unlike them, since he does not wait for the sudden advent of transcendence, he eternally wanders around senselessly like a will-o'-the-wisp, and returns like a ghost.

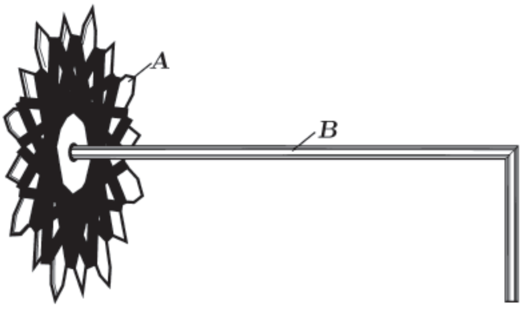

Fig. 1: Reconstruction of Odradek from descriptive text;
A: star-shaped spool, B: wooden crossbar.

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6 More on inversion, especially in Hegel and Freud, can be found in D. Link, *Poesiemaschinen / Maschinenpoesie* (Munich, 2007), pp. 66–69.

7 Julien Offray de La Mettrie, *L'homme machine* (Leyden, 1748). The mechanistic view of human beings seems reasonable, because the basis of their complex behaviour, including thought, is obviously material.

8 G. Anders, *Kafka pro und contra* (Munich, 1951), p. 12f. (Translation mine, D.L.) Throughout this essay based on a lecture held in 1934, Anders calls Odradek "Odvadek", without specifying any reason. In Hungarian, "odvas" means "dry-rotten, scooped out, decayed".

By contrast the father guarding the house fulfils the minimal function of being there, keeping his eyes open, and taking care of problems if necessary. That he is located at the border between duty and futility endows him with the time to reflect on what he encounters, an autonomous artefact with no purpose at all. He does not care about Odradek, but is concerned about himself. He suspects that even if the senseless thing copies several characteristics of human beings, it might be immortal or at least more durable than he himself, because it does not wear itself out in the pursuit of an aim. One of Anders' main concepts, the "promethean shame", bases on a similar train of thought. Human beings feel embarrassed vis-à-vis their products, because they seem perfect compared to themselves and possess a higher durability, which is brought about by "platonoidisation". Anders takes the light bulb as an example. If it burns out, he argues, it can be replaced by another one in a process of "industrial reincarnation", because it is only one out of millions of objects realising the same idea, which represents the essence of the product.[9]

Marshall McLuhan called "electric light […] pure information" and "the medium without a message".[10] The bulb neither fits the category of "tool" or "instrument", nor that of "medium". It does not allow one to manipulate other objects, to produce scientifically interesting effects or to observe yet unknown aspects of nature, nor does it convey a message of any kind. Hence the more general term "artefact" will be used in this article to denote things that have been skilfully produced to serve a certain purpose, either directly or indirectly.[11] These objects possess a second, symbolic level or a "matrix", as Anders calls it, which is constituted by the concept of a desired function (artificial light in the case of the bulb) and the idea of an implementation, the association of material elements in a certain *technical form*.[12] Seen from a momentary perspective, this in fact results in an "eternalisation". But in a more historical view, its effects might serve as a consolation for the house father as well as for the human beings embarrassed by "promethean shame": Different from a piece of wood, artefacts disintegrate on several levels and may suffer, as it were, several different deaths:

(1) The desired function might become obsolete, due to change of needs, fashion, or realisation of its impossibility. An example of the last class of aims is the making of gold from less valuable material undertaken by alchemists for several hundred years and leading amongst other things to the Western recipe for porcelain.

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9 Anders, *Antiquiertheit*, p. 51.

10 Marshall McLuhan, *Understanding Media. The Extensions of Man* (New York, 1964), p. 8.

11 Latin *ars* – skill and *facere* – to make: something skilfully produced.

12 Cf. the etymological elaborations of Heidegger on the connection of "Zeug" (artefact), "Zeigen" (pointing) and "Zeichen" (sign), in Martin Heidegger, *Being and Time* [1927], trans. John Macquarrie and Edward Robinson (New York, 1962), pp. H 68–83.

(2) Another artefact might be invented to better implement the desired function, thus rendering the old one obsolete, as the line of inventions candle – kerosene lamp – gas lamp – incandescent light bulb shows for artificial illumination.

(3) The material basis might disintegrate to a point where it becomes unusable, parts might fall off or wear out, etc.

2. The Idealisation of Artefacts

The symbolic level of the artefact is realised by configuring a certain material association of individual components. The statement of McLuhan's media theory that "the 'content' of any medium is always another medium" should be reformulated in this context: The components of an invention are in most cases artefacts devised earlier.[13] The light bulb owes its existence to the craft of glassblowing, the invention of the mercury vacuum pump, the generation and transmission of electricity, etc. If the association reaches a certain complexity, for example, in mechanical apparatus, an uninitiated observer can no longer easily read off the intended function from the form, especially if it serves an uncommon, specialised purpose. Consequently, Anders diagnoses alienation of human beings from their artefacts:

"The object ['Odvadek'] reminds us of all sorts of items and machines which modern man has to handle day in, day out, even though their performance seems to have nothing to do directly with the *needs* of human beings. Thousand-fold, the contemporary human being is confronted with apparatuses whose purpose is unknown to him, and to which he can only maintain 'alienated' relationships, because their relations to the human system of needs are indefinitely mediated."[14]

Incandescent light bulbs stand at the beginning of a development in which this quality of being enigmatic becomes aggravated. The German economist and philosopher Alfred Sohn-Rethel called them "inscrutable spiritual beings" in his brilliant essay on the Italian way to deal with technology, and noted that in this southern country, these artefacts "which always leave one wondering if they are even of this world […] flow together uninhibitedly with the nimbus of the religious powers, and the festive Osram bulb is united, in Neapolitan saintly images, with the Madonna's aureole".[15] With mastery of the invisible force of electricity, artefacts started to get "plato-

13 McLuhan, *Understanding Media*, p. 8. This point is well illustrated by the technical trees incorporated in computer strategy games like "Civilization" by Sid Meyer (1991), even if sometimes, due to misconception, it is possible to invent the tank before the wheel.

14 Anders, *Kafka*, p. 11.

noidised", or better, idealised in a sense different from Anders'. The light bulb no longer achieved a material effect in the world, but merely a visual one, and one component of the implementation was invisible — the electric current. The "medium without a message" developed further into media with a message, imaginary artefacts like film projectors, when semitransparent material was put in front of it. The success of these apparatuses and the market for immaterial commodities they made possible at first highly astonished traders of ordinary goods. To them, these machines, which produced "nothing", must have seemed as absurd as Odradek. The cloth merchant Carl Laemmle "had never seen such a rush of customers, and started to count the masses, marvelling", when he came upon a cinetoscope show, and then decided to take part in the new business. His Independent Moving Picture Company merged with other studios in 1912 to become the Universal Film Manufacturing Company, one of the biggest film production facilities in the early years of the medium.[16] Siegfried Zielinski has pointed out that already at the beginning of the eighteenth century, both stock dealers and *laterna magica* projectionists were ridiculed as "traders of wind".[17]

In their implemented form artefacts possess an ambiguity that allows them to be reinterpreted experimentally. In 1904, the British electrical engineer and physicist Ambrose Fleming slightly modified the material association of the light bulb by incorporating a second wire into the vacuum tube and created the first component that was no longer electric, but electronic (cf. Figure 2). Fleming had worked for Edison's company in London, where he became interested in the "molecular shadow" inside lamps, already noted by the American inventor, which was caused by the emission of negative particles from the incandescent filament.[18] In his "Instrument for converting alternating electric currents into continuous currents", electricity only flowed in one direction, from the heated cathode to the anode, in the form of a "cathode ray". Its original function was to make "feeble electric oscillations [of

15 Alfred Sohn-Rethel, Das Ideal des Kaputten. Über neapolitanische Technik [1926], in: *Das Ideal des Kaputten* (Bremen, 1990), pp. 33–38, p. 35f. English translation online, The Ideal of the Broken-Down, http://www.formundzweck.com/eng/autoren.php?S+Sohn-Rethel+Alfred. Thanks to Alexandre Métraux for bringing this article to my attention.

16 René Fülöp-Miller, *Die Phantasiemaschine. Eine Saga der Gewinnsucht* (Berlin, 1931), p. 11f. The next such astonishment might occur when the "industry of consciousness" resulting from this trade of immaterial goods realises that digitisation and instant electronic communication have rendered its products unsaleable. Since they can be copied and communicated at will, virtual objects can only be transacted once between the producer and the market as a pool of common intellectual property. Because of the lack of precedents, it cannot be estimated whether they still constitute commodities.

17 Cf. Siegfried Zielinski and Silvia Wagnermaier, eds., *Variantology 1* (Cologne, 2005), p. 144. The author is also indebted to S. Zielinski for suggesting the form of prolegomena for the present article.

18 Cf. Thomas A. Edison, Electric lamp (Patent no. US 223,898, 4 November 1879) and Gerald F. J. Tyne, *Saga of the Vacuum Tube* (Indianapolis, 1977), pp. 31–51.

alternating current], such as are employed in […] telegraphy" "detectable by and measurable with ordinary direct current instruments".[19] The rectifier or diode was incorporated into the Marconi-Fleming valve receiver for wireless telegraphy from 1905 onward.

Two years later, the U. S. American inventor Lee de Forest added another electrode to the setup and created a second artefact with an invisible function, the "Audion".[20] The electron cloud at the heated cathode was attracted to the anode when a feeble positive charge was applied to a control grid located between the two. In this way, currents of various strengths could be switched without any material and therefore inert components interfering. Since the flow to the anode was proportional to the charge on the grid, the device could in principle also be used as an amplifier. It was built into a number of radiotelephone sets that his company sold to the U. S. Navy in 1907.[21] Before copying and extending Fleming's artefact, de Forest had tried to achieve the same effect by modifying Bunsen burners. That he developed the Audion more by experiment than by concept is further evinced by the fact that he did not understand the reason why his invention worked: "[T]he explanation is exceedingly complex and at best would be merely tentative".[22]

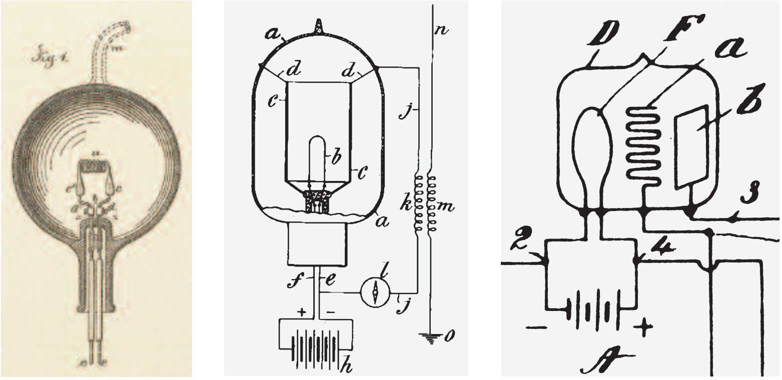

Fig. 2: Three examples of idealised artefacts: light bulb, 1879; diode, 1904; triode, 1907.

19 John Ambrose Fleming, Instrument for converting alternating currents into continuous currents (Patent no. US 803,684, 19 April 1905, first applied for in England, GB 24,850, 16 November 1904), p. 1. All patents quoted are accompanied by their date of application.

20 Lee de Forest, Device for amplifying feeble electrical currents (Patent no. US 841,387, 25 October 1906) and Space telegraphy (Patent no. US 879,532, 29 January 1907).

21 Tyne, *Saga*, pp. 52–72.

22 De Forest, Space telegraphy, p. 1.

The light bulb created an immaterial, but visible effect, whereas in the electron tube it was immaterial and invisible, constituting an "ideal artefact", in which some parts and, more importantly, its purpose were located in the realm of sub-atomic particles and the waves that could be formed out of their beams. In the space without air, the material resistance that had defined natural matter since antiquity was suppressed and, consequently, the component reacted almost without delay.

As a result, the implemented functions looked increasingly identical from the outside and could only be differentiated by an expert, by using special measuring equipment, which evolved out of the same scientific and engineering movement and at the same time, like Karl Ferdinand Braun's instrument for "the demonstration and study of the temporal sequence of variable currents" invented in 1897.[23] The component that performed its task in invisibility became opaque itself and transformed into a black box. If an external observer was not instructed by documentation or the cultural knowledge around him, it might have seemed as absurd as Odradek to him, because its significance could no longer be read from its form. The enigmatic quality of artefacts increased even more when these components were in turn integrated into bigger, more complex devices like radio receivers. They encapsulated functionality into single elements that each served a certain purpose, but created the desired effect through their interplay. Similar to a rebus, where the meanings of pictures of objects and letters have to be combined to guess at the sentence represented, when confronted with complex idealised machinery, the observer first has to find out the sense of the different components, and then combine them to derive the overall purpose (cf. Figure 3).[24]

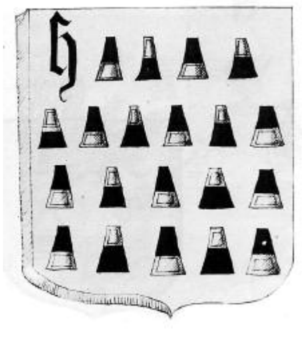

Fig. 3: A riddle from the Rébus de Picardie, 1506.

23 Ferdinand Braun, Über ein Verfahren zur Demonstration und zum Studium des zeitlichen Verlaufes variabler Ströme. *Annalen der Physik und Chemie. Neue Folge* 60 (1897): 552–559. The predecessor of today's "oscilloscope" antedates the first "ideal artefact", a "diode" in modern terminology, by seven years.

24 Cf. Jean Céard, ed., *Rébus de Picardie: les manuscrits f. Fr. 5658 et 1600 de la Bibliothèque nationale* [~1499–1506] (Paris, 1986), no 15-XIV. "H" (letter name pronounced "ash" in French) is followed by "vingt pions", twenty pawns: "ch'vin pions" – "This wine we drink."

To enable their possessors to deduce and use the functionality of complex and, later, idealised artefacts, their constructors complemented them with a manual. For similar reasons, Great Britain required a written specification for the application of patents in the early eighteenth century, and the explanatory text on the "new and useful improvements" was soon illustrated by additional technical drawings.[25] Whereas for natural objects, only the matter has to be protected against deterioration to secure their survival, for more complex artefacts documents also have to be preserved that ensure their readability and comprehensibility. The practice of writing manuals spans a history of several hundred years. A text from the Middle Ages, for instance, describes the procedure of how to probe the depth of a sea or river with the instrument of the astrolabe. The explanations given only work partially, because apparently reliable and unreliable sources were mixed. Authors that only copy the descriptions of others without having used the device endanger the transmission of the vital information by adulterating it.[26] Anders accentuates the creation of durability by "platonoidisation", but the fact that these objects need to be understood to survive actually renders them very fragile.

During its lifetime, the performance of the material setup visibly resolves its mysteriousness, but when it breaks or becomes obsolete and stops, the enigma emerges. Intellectual and practical effort is then necessary to reconstruct it. The longer this does not take place, the more the unreadability increases, up to a point where even its former overall purpose is forgotten, either because its documentation was lost, or because it was ripped out of a larger machine context, or because its material basis was mutilated. The artefact gets into this peculiar situation of Odradek-like mysteriousness, because it is not sufficiently charged by interest in it.[27] Being purposeless and no longer understood, the thing loses its place in the world, the location where it was effectively used, and starts to wander around:

"'Well, what's your name?' you ask him. 'Odradek,' he says. 'And where do you live?' 'No fixed abode,' he says and laughs; but it is only the kind of laughter that has no lungs behind it. It sounds rather like the rustling of fallen leaves."[28]

The obsolete artefact does not worry inventors, engineers, or factory owners trying to make it as effective as possible, but only people that have the leisure to be troubled by

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25 Jakkrit Kuanpoth, The political economy of the TRIPS agreement, in: *Trading in Knowledge*, ed. Graham Dutfield, Ricardo Meléndez-Ortiz, and Christophe Bellmann (London, 2003), pp. 45–56, p. 46.

26 Arianna Borrelli, The flat sphere, in: *Variantology 2*, eds. S. Zielinski and D. Link (Cologne, 2006), pp. 145–166, especially pp. 148–151 and 164–166.

27 Slavoj Žižek in contrast interprets Odradek as "jouissance", because he is purposeless, and later, as "libido as organ". Slavoj Žižek, Odradek as a political category. *Lacanian Ink* 24/25 (2005): 136–155.

28 Kafka, Cares of a Family Man, p. 428.

its mysteriousness, like the house father. Many websites of enthusiasts of obsolete technology contain a section with photos of unidentified components asking the visitor for help with appeals like "No idea what this fine piece of technology is. It has a number W75 309-1-A. Any comments and offers appreciated." (cf. Figure 4)[29]

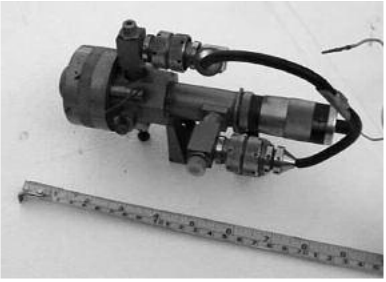

Fig. 4: Enigmatic object from a website specialising in historic valves.

3. Reconstructing Odradek, I.

In a newspaper article in 1934 (the same year as Anders' lecture) commemorating the tenth anniversary of Kafka's death, the German philosopher Walter Benjamin wrote about "the most peculiar bastard in Kafka that the Prehistoric has conceived with the Guilt": "The attics are the location of the discarded, forgotten effects. […] Odradek is the form that things assume in oblivion. They are disfigured."[30] In the last sentence, he uses the word "entstellt", which signifies, according to Grimm's German dictionary: "aus der rechten stelle, fuge oder gestalt bringen" (to get out of the right place, junction, or shape), while "fuge" is explained as "die enge verbindung zweier aneinander passender theile" (the narrow joint of two parts fitting to each other).[31] In German the word once meant to have been forced away from the right, the fitting location.

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29 Crowthorne Tubes website, http://www.crowthornetubes.com/weird.htm.

30 Walter Benjamin, Franz Kafka. Zur zehnten Wiederkehr seines Todestages [1934], in: W. Benjamin, *Gesammelte Schriften*, vol. II 2 (Frankfurt am Main, 1977), pp. 409–438, quotation p. 431: "Der sonderbarste Bastard, den die Vorwelt bei Kafka mit der Schuld gezeugt hat, ist Odradek. […] Die Böden sind der Ort der ausrangierten, vergessenen Effekten. […] Odradek ist die Form, die die Dinge in der Vergessenheit annehmen. Sie sind entstellt." English translation: W. Benjamin, Franz Kafka: On the Tenth Anniversary of His Death, in: *Illuminations*, trans. Harry Zohn (New York, 1969), pp. 111–140, quotation p. 127.

31 Jacob and Wilhelm Grimm, *Deutsches Wörterbuch* (Frankfurt am Main, 2004), entries "entstellen" und "fuge".

The broken construction is reminiscent of the instructional child game of the "spool racer". The experimenter inserts a rubber band through the hole in a spool, fixes it with a toothpick, and then winds it up with a pencil at the other end. Releasing the device results in fast rotation of the spool, which sets the construction in rapid and rather uncontrolled motion.[32] If we consider Odradek as an obsolete artefact that has lost its place and now wanders around as an enigma, we could speculate that a part of it is missing and renders it unreadable. If another rod were added to the crossbar that sticks out of the spool, it already starts to look more useful (cf. Figure 5).[33]

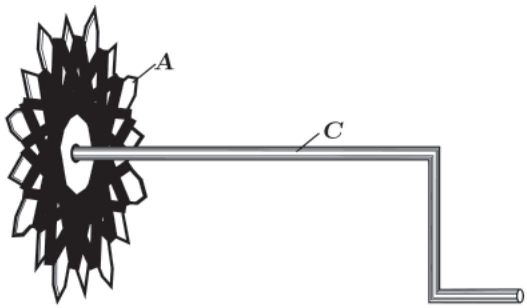

Fig. 5: A speculative attempt at reconstruction of Kafka's Odradek; A: star-shaped spool, C: crank lever.

The crank lever could indicate that the artefact was used in the context of a bigger mechanical assembly. Around thirty years before Kafka wrote his story, in 1887, the British engineer John Keats patented an "apparatus for winding thread". At that time, the biggest challenge facing shoe manufacturers in England was to mechanise their production to be able to compete internationally.[34] While many of his guild emphatically opposed the new developments, the poet's namesake took up the challenge and in 1864 solved one of the most difficult problems, the mechanical fastening of a sole to an upper. He invented a specialised sewing apparatus, the "Crispin", in collaboration with the owner of a big shoe company in Street, Somerset, William S. Clark of C. & J. Clark, which still exists today.[35] In the 1870s, Keats devised a machine for "twisting

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32 Cf. John Graham, *Hands-on Science. Forces and Motion* (New York, 2001), p. 8.

33 The author wishes to thank the cobbler Willi Schiffer, Cologne, for this suggestion, personal communication, 25 February 2007.

34 Cf. George B. Sutton, The marketing of ready-made footwear in the nineteenth century, in: *Capital, Entrepreneurs and Profits*, ed. Richard P. T. Davenport-Hines (London, 1990), pp. 41–60. For the full history of the company, cf. G.B. Sutton, *C. & J. Clark 1833–1903. A History of Shoemaking in Street, Somerset* (York, 1979), especially pp. 131–167.

35 Boot-making machinery, in: *Spon's Dictionary of Engineering*, ed. Edward Spon and Oliver Byrne (Oxford, silk thread", which was built by the engineering manufacturer Greenwood & Batley in Leeds and exhibited at the International Exhibition held in Vienna in 1873.[36] He then turned to the mechanically complicated problem of winding up yarn and conceptualised and improved the necessary apparatus in the six years between 1887 and 1893.[37] He died around 1902, as documented by several posthumous patents applied for by his son (cf. Figure 6).[38]

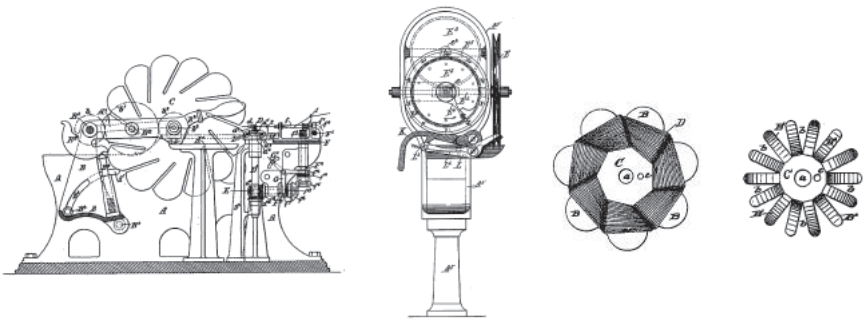

Fig. 6: Keats' winding machine, 1887, its cutting mechanism, and two of his star-shaped holders.

Keats' "apparatus for winding thread" was driven manually by a crank handle, shifted the yarn from left to right, and slid it through the slots of a rotating, star-shaped disk, "the laps of thread being made alternately on opposite sides of the thread-holder and upon each spur or arm in succession, or on two spurs or arms in succession".[39] In the second version of the machine, the size of the spool ("five, seven, nine, or eleven spurs") and the kind of winding could be controlled by a gear shift. The quantity of thread on the disk was measured and when a certain length had been reached, the apparatus automatically cut it and switched off. Winding thread in this

1869), vol. 1, pp. 485–498, especially p. 495; and Sutton, *C & J Clark*, pp. 145–148. The corresponding patent is: John Keats and William S. Clark, Improvement in sewing-machines (Patent no. US 50,995, filed in England on 11 October 1864). All shoes sold by Clarks today are manufactured in the Far East.

36 Keats' silk thread twisting machine. *Engineering Weekly* (22 January 1875): 61 and 63.

37 J. Keats, Apparatus for winding thread (Patent no. US 440,811, filed in England on 12 January 1887); J. Keats, Holder for thread (Patent no. US 440,812, filed in England on 12 January 1887); J. Keats, Machine for winding thread upon disk-holders (Patent no. US 456,671, 3 September 1890); J. Keats, Machine for winding thread upon star-shaped holders (Patent no. US 543,185, filed in England on 14 January 1893). Cf. H. Glafey, Maschine zum Aufwickeln von Fäden auf Garnhalter mit sternförmigen Armen. *Dingler's Polytechnisches Journal* 269 (1888): 248–250, and H. Glafey, Maschinen zum Aufwickeln von Fäden auf Garnhalter mit sternförmigen Armen. *Dingler's Polytechnisches Journal* 285 (1892): 221–225.

38 J. Keats, Machine for preparing the soles of boots or shoes (Patent no. US 742,444, applied for by John Charles Keats, 26 September 1902).

39 Keats, Machine for winding thread upon star-shaped holders, p. 1.

way was much easier than with round spools, because the yarn did not need to be guided continuously up and down the body of the roll. Keats wrote that the "holder of novel construction" would, moreover, "display the thread in a better manner" and "present advantages in unwinding not hitherto possessed by thread-holders", because the thread would "run off in the plane of rotation of the holder, and that in a smooth and uniform manner, the only deviation from a straight line being due to the thickness of the material of which the arms of the holder are made."[40] The star-shaped disks that he preferably produced from "glazed card board", but also mentioned "wood, or metal sheets" as possible materials, later proved useful for soldiers so they could repair their uniforms (and the flesh wounds under it) in the field; they could not carry spools on them that might break and possibly injure them when jumping on the ground.[41]

That the crossbar, like the whole of Odradek, is made of wood in Kafka's story may indicate that either the object belongs to machinery of an even earlier era, or that the author tried to prevent it being interpreted as an obsolete artefact or part of apparatus from the past. The remark in the paragraph following the one cited above points in this direction, but Odradek's agility prevents any definite conclusion:

"One is tempted to believe that the creature once had some sort of intelligible shape and is now only a broken-down remnant. Yet this does not seem to be the case; at least there is no sign of it; nowhere is there an unfinished or broken surface to suggest anything of the kind; the whole thing looks senseless enough, but in its own way perfectly finished. In any case, closer scrutiny is impossible, since Odradek is extraordinarily nimble and can never be laid hold of."[42]

That no sign of breakage can be observed is consistent with the above interpretation, since it would be hidden under its right leg. The case that the enigmatic association of material components has never existed will be covered in Section 7 below.

In Kafka's time, around 1915, the technique and form of the thread star reappeared in the context of the cheap and mostly home-made crystal radio receivers, consisting only of an antenna, a coil and an earphone, without any power supply. In the infancy of the medium "radio hams" tried to ameliorate the reception of the AM waves by devising spools in a large variety of shapes. "Honey comb" and "spider web" coils, based on the form of a star and wound similar to those in Keats' invention, proved to be very effective in this respect and were widely adopted (cf. Figure 7).[43] From 1909

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40 Keats, Holder for thread, p. 1f.

41 The author is indebted to Rudi Wache, Amann Sewing Threads GmbH Bönnigheim, for this information. Personal communication, 1 March 2007.

42 Kafka, Cares of a Family Man, p. 428 (Translation slightly altered, D.L.).

onward, Kafka's fiancé Felice Bauer worked at the Carl Lindström A.G. in Berlin and marketed the "Parlograph", an early dictating device that recorded on wax cylinders.[44] In 1924, the year of the writer's death, the company brought out its first radio, the G1.

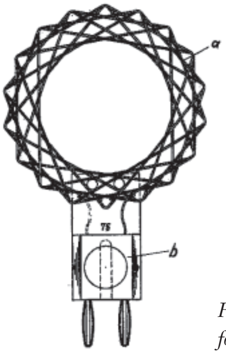

Fig. 7: Star-shaped spool for radio, Carl Gamke, 1927.

While application areas, implementations, and concrete objects pass away, certain basic techniques or *schematic forms* are put into practice again and again.[45] The obsolete, enigmatic artefact Odradek keeps returning:

"Often for months on end he is not to be seen; […] but he always comes faithfully back to our house again."[46]

The winding method of these antennas and of the thread star originated from the craft of basketry; more specifically, from procedures like the triple twist, where the weavers are placed between three consecutive spokes and are brought in succession over two and under one of them.[47] The knowledge of technical *schemata* incorporated in the

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43 They were patented in Germany by Carl Gamke, Flachspule nach Art einer Korbspule (Patent no. DE 484,261, 15 February 1927).

44 Sander L. Gilman, *Franz Kafka* (London, 2005), p. 61.

45 Cf. I. Kant, Of the schematism of the pure concepts of the understanding, in: *Critique of Pure Reason* [1781], trans. Norman K. Smith (London, 1933), A137–A147, A138: "How, then, is the *subsumption* of intuitions under pure concepts, the *application* of a category to appearances, possible? […] Obviously there must be some third thing, which is homogeneous on the one hand with the category, and on the other hand with the appearance, and which thus makes the application of the former to the latter possible. This mediating representation must be pure, that is, void of all empirical content, and yet at the same time, while it must in one respect be *intellectual*, it must in another be *sensible*. Such a representation is the *transcendental schema*."

46 Kafka, Cares of a Family Man, p. 428.

47 Cf. Anna A. Gill, *Practical Basketry* (Philadelphia, 1916), p. 29. Archaeological finds indicate it is older than pottery; the earliest objects are dated to approximately 10,000 BCE; cf. George W. James, *Indian Basketry* (Kila, MT, 2005), p. 13: "There is no question that baskets preceded pottery making".

artefact can be transcribed into different inventions in other contexts after it has become useless. Sohn-Rethel observed a spectacular instance of such a transfer: "A further example would be the wheel-motor, which, liberated from the constraints of some smashed-up motorbike, and revolving around a slightly eccentric axis, whips the cream in a latteria." His analysis that for the Italian "the essence of technology lies in the functioning of what is broken" and that hence the artefact quickly oscillates between effectiveness and defect, is mirrored by processes of technical recurrence or reincarnation that span enormous periods of time.[48]

In a theoretically momentous report for the "Conseil des universités" of Quebec in 1979, the French philosopher Jean-François Lyotard denied the possibility of general and coherent theoretical accounts altogether: "The grand narrative has lost its credibility, regardless of what mode of unification it uses, regardless of whether it is a speculative narrative or a narrative of emancipation."[49] That this proposition is without substance can already be seen from the fact that it is paradoxical (in a weak sense). If all unifying accounts have lost their credibility, then so has Lyotard's very general one about delegitimation. It follows logically that some are exempt from this rule, as in the classical case of the lying Cretan. The history of ideas has to continue to tell "grand narratives" to reduce complexity, otherwise it turns into an extremely voluminous, unordered list of facts. "A theory is good only to the extent that it compresses the data into a much smaller set of theoretical assumptions and rules for deduction", writes Gregory Chaitin in an article on uncertainty in mathematics, a discipline shaken by crisis much more than the "soft" sciences, because it possesses methods of falsification.[50] Even if Chaitin's formal requests cannot be fulfilled in the history of ideas, one of the more stable fundaments it can rely on in its quest for lossless reduction of complexity are technical artefacts, because these materialised thoughts travel with slower relative speed in the stream of time than the narratives that conceive and accompany them. Unlike hermeneutic fiction and free association, their identity over time can be proven, and their possible functionalities can be experienced and experimented with at will.

The science historian Hans-Jörg Rheinberger has summarised this research strategy with admirable clarity: "My emphasis is on the materialities of research. […] My approach tries to escape this 'theory first' type of philosophy of science [like underlining the theory-ladenness of observation in the footsteps of Lyotard]. For want of a better term, the approach I am pursuing might be called 'pragmatogonic'." "Instead of reading a history of objectivity from concepts, I embark on reading a history of *objec-*

48 Sohn-Rethel, *Ideal des Kaputten*, p. 37 (Translation altered, D.L.).

49 Jean-François Lyotard, *The Postmodern Condition: a Report on Knowledge* [1979] (Manchester, 1984), p. 37.

50 Gregory J. Chaitin, Computers, paradoxes and the foundations of mathematics. *American Scientist* 90. 2 (2002): 164–171, quotation p. 170.

ticity from material traces."[51] Historical materialism is "turned off its head, on which it was standing before, and placed upon its feet".[52]

4. Reconstructing Odradek, II.

The second thought experiment in reconstructing the technical schemata Kafka was copying for Odradek starts with another close reading of the only remaining information: several paragraphs written not by the inventor of the device, but by an external observer. The rod leaves the star-shaped spool in the middle, but probably we deduced the setup of Figure 1 too early, and should have included in the possible configurations the one shown in Figure 8, which was created by turning the wheel 90 degrees around the y-axis (cf. Figure 8).

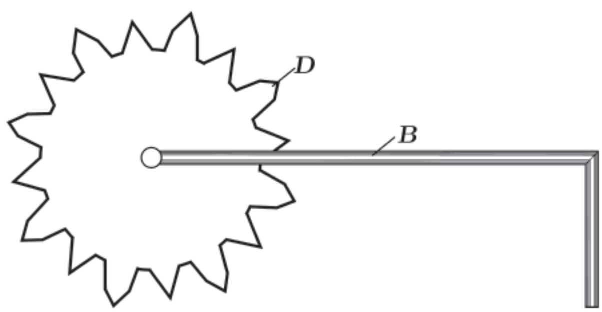

Fig. 8: Another speculative attempt at reconstruction of Kafka's Odradek; B: supporting bar, D: star-shaped disk.

Very probably, Kafka was introduced to such a device made of iron when he visited the secondary school "Altstädter Deutsches Gymnasium" in Prague from 1893 to 1901. The English mathematician and natural philosopher Peter Barlow devised it in 1822 in the context of experiments on electromagnetism, and demonstrated that current could produce rotary motion (cf. Figure 9).[53] He mounted a star-shaped wheel on an axis above a trough of mercury in such a way that its points made contact with the

51 Hans-Jörg Rheinberger, *Toward a History of Epistemic Things. Synthesizing Proteins in the Test Tube* (Stanford, 1997), p. 26 and 4.

52 Friedrich Engels, *Ludwig Feuerbach and the Outcome of Classical German Philosophy* [1886] (New York, 1941), p. 44.

53 It was first mentioned in a letter to Michael Faraday on 14 March 1822, cf. *The Correspondence of Michael Faraday*, ed. Frank A. J. L. James (London, 1999), p. 254f.

electrically conducting liquid. When he applied current, it flowed along the radius of the disk and produced a field that interacted with a permanent or electric U-magnet located under it. "In effect, the points of the wheel constituted a series of wires radiating from the axle".[54] The star-shaped disk started to revolve.

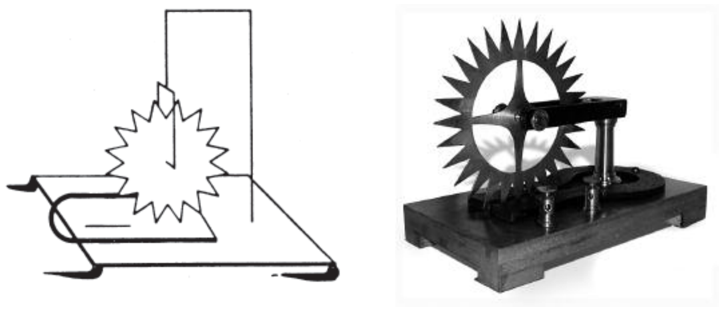

Fig. 9: Barlow's wheel, original drawing, 1822, and demonstration apparatus, ca. 1890.

While the invention demonstrated the possibility of electro-mechanical motion, it did not realise it effectively enough to be useful as driving force for machinery. The final setup presumably emerged from a series of experiments with earlier prototypes, whose components and forms we do not know. A direct predecessor, however, is known, Michael Faraday's revolving wires from 1821.[55] He suspended an electric filament next to a permanent magnet into a cup of mercury, and when he applied current to it, due to the field generated, it started to rotate. Barlow's wheel was a popular object for demonstrations in physics classes and several companies continued to produce it even after it had been superseded, well into the twentieth century. Further developments by several inventors in the nineteenth century turned the tinkered, experimental setup into a most useful and, after some time, also robust artefact: the electrical motor, which allowed things to move around "nimbly" like Odradek, when it was used to drive their wheels. The fragile association produced by a *bricoleur* provided functions that could be used in a variety of contexts outside the laboratory, and was consequently transformed into a unified component.[56] Brushes replaced the impracti-

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54 Thomas B. Greenslade, Jr., Apparatus for natural philosophy: Barlow's wheel. *Rittenhouse* 1 (1986): 25–28, p. 27. Cf. Daniel Davis, *Davis's Manual of Magnetism* (Boston, 1852; online: http://name.umdl.umich.edu/ajn7462.0001.001), pp. 103–115. Cf. L. Pearce Williams, ed., *The Selected Correspondence of Michael Faraday, vol. 1: 1812–1848* (Cambridge, 1971), p. 132f. My thanks go to John D. Jenkins for providing the high-resolution image of the wheel shown at the Spark Museum, http://www.sparkmuseum.com/MOTORS.HTM.

55 Michael Faraday, On some new electromagnetical motions, and on the theory of magnetism. *Quarterly Journal of Science and Art* 12 (1821): 74–96.

cal trough of mercury. and the device was hardened by applied engineers to withstand the randomness of ignorant widespread use. The resulting reliable technical element could then be used, in turn, as a part in a newly invented, tinkered setup to create effects more interesting than the by then standardised electric motor.

Figure 10 shows three experimental artefacts from approximately the same period that never became effective outside the laboratory — or probably not yet.[57]

Fig. 10: Demonstration apparatus from the nineteenth century.

The line of very early computers developed at the University and the firm of Ferranti in Manchester from 1948 to 1951 serves as an example of what happens when complex idealised machinery becomes obsolete. If it is reasonable to regard a group of engineers that deploys the possibilities of a certain technology as a "culture", united by a set of objects, theories, and methods, then the title of a once popular fiction story might be suitable for the discussion.[58]

5. The Last of the Mohicans

The electrical engineer Frederic C. Williams (1911–1977) developed the first reliable means of volatile, random-access memory, the Williams tube, at Manchester University in 1946 (cf. Figure 11). He was joined in this effort by an assistant, Tom Kilburn (1921–2001), who in large part worked out the intricate technical details.[59] On the

56 Cf. H.-J. Rheinberger, From experimental systems to cultures of experimentation, in: *Concepts, Theories, and Rationality in the Biological Sciences*, ed. Gereon Wolters and James G. Lennox (Konstanz, 1995), pp. 107–122, p. 111: "Scientists are *bricoleurs*, not engineers."

57 The reader is invited to guess at their purpose.

58 Cf. James F. Cooper, *The Last of the Mohicans* (Philadelphia, 1826).

Fig. 11: Williams tube, 1946.

screen of a standard cathode-ray tube (CRT) 1280 dots were detected by a pickup-plate in front and regenerated before they faded away. At first, the engineers manually switched the bright points on and off with a keyboard.[60] To test if their store would also work reliably when operated quickly and in a mode of random access, they built a very simple, but Turing-complete computer around it, the Manchester "Baby" prototype (1948). It evolved organically into the Manchester Mark I (1949) and the Ferranti Mark I (1951), of which two machines were delivered to the Computer Departments at Manchester and Toronto University.[61]

When the first machine using the volatile memory was produced industrially in 1951, the feet of those who would carry the newly invented technology out were already at the door.[62] Core store had been developed in 1949 by An Wang from Harvard University and been incorporated into the flight simulator project "Whirlwind" at the Massachusetts Institute of Technology (MIT) by Jay Forrester (cf. Figure 12). From 1954 on, it was commercially available in the form of IBM's 737 magnetic core unit, and by the mid 1950s, most major computer manufacturers had switched to the new technology.[63] At the end of the decade, industrial plants set up

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59 Frederic C. Williams, Improvements in or relating to electrical information-storing means (Patent no. GB 645,691, 11 December 1946).

60 F.C. Williams and T. Kilburn, A storage system for use with binary-digital computing machines. *Proceedings of the Institution of Electrical Engineers Pt. II* 96 (March 1949): 183–202, here p. 193.

61 For the emergence of the storage technique out of radar research and a discussion of early programming on these machines, see D. Link, There must be an angel, in: *Variantology 2*, eds. S. Zielinski and D. Link (Cologne, 2006), pp. 15–42.

62 Cf. G.W. F. Hegel, *The Phenomenology of Mind*, trans. James B. Baillie (Mineola, 2003), p. 43, and Acts 5:9: "Behold, the feet of them which have buried thy husband are at the door, and shall carry thee out."

63 The U.S. American IBM 701, announced 1952, and the 702 a year later used Williams tubes, while the 704 in 1954 employed core memory; the American UNIVAC 1103 from 1953 operated on Williams tubes, the 1103A in 1956 on core memory; so did the Edsac II from 1957 built in Cambridge, UK, and the American Illiac II from 1962, which had relied on mercury delay lines before. The latest integration of Williams tubes was in the Russian Strela-1 computer, which was produced between 1953 and 1956 at the Moscow

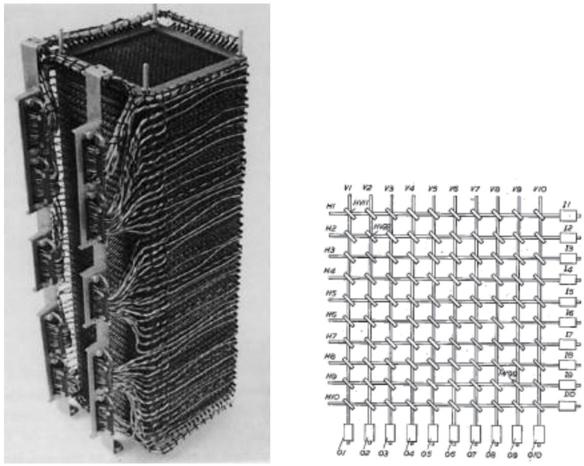

Fig. 12: Core memory, Wright 1951 (Patent no. US 2,667,542).

in the Far East lowered the cost of the component considerably.[64] In 1954, the team under Tom Kilburn completed the next computer at Manchester University, "MEG", employing Williams tubes for storage. Before producing it and marketing it as "Mercury" in 1957, the Ferranti company replaced them with core memory. One of these machines was installed in the Computing Laboratory of the University in the same year and superseded the Ferranti Mark I, which was dismantled in June 1959.[65] The culture of electrical engineers modifying CRTs in intricate ways with the purpose of storing data in them, their technological progress and insights into the properties of the material setup did not last; it only endured for a brief period of eight years.

After that, the originator of the idea to use radar tubes as volatile memory, Frederic Williams, worked on other components, mainly electrical motors. He stayed in the Electrical Engineering Department when the Computer Science Department broke away from it in 1964 and died in 1977. The newly founded institution was headed by his colleague Tom Kilburn and developed the next few generations of computers, adopting to the next few generations of technology: MEG/Mercury from 1951 to 1954, in parallel with the Transistor Computer, MUSE/Atlas from 1956 to 1962 (built

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Plant of Computing–Analytical Machines. Cf. Edwin D. Reilly, ed., *Concise Encyclopedia of Computer Science* (Chichester, 2004), p. 262ff., and Simon Lavington, *Early British Computers* (Manchester, 1980), pp. 31–35.

64 Cf. Robert Slater, *Portraits in Silicon* (Cambridge, MA, 1987), p. 97.

65 Martin Campbell-Kelly, Programming the Mark I: Early programming activity at the University of Manchester. *Annals of the History of Computing* 2[2] (1980): 130–168, especially p. 131.

from core store and transistors), and MU5 from 1966 to 1974 (based on integrated circuits and core store).[66] Every time a new component was invented, the knowledge of the *bricoleurs* was rendered obsolete: "For engineers, the juggernaut of ever-changing technology presents a constant problem of learning new things and a reluctance to forget the old, in case the old may turn out to be useful."[67] If they can no longer keep up with the speed of developments, they are regarded by those around them as the last of an exotic tribe almost extinct, as Mohicans, in a mixture of respect and pity. Kilburn retired in 1981 and died in 2001.[68]

Every time the Computer Science Department built a new machine, the old ones were disassembled, so their parts could be re-used in other projects. This is why only singular components remain, like several of the double Williams tubes from the Ferranti Mark I, several doors of electronics, and possibly the original 19" steel rack of the prototype.[69] Earlier computing apparatus suffered a similar fate, albeit for other reasons. The code-breaking machinery of the British, "Colossus", was ordered to be destroyed into "pieces no bigger than a man's hand" by Churchill after the war, some parts being secretly taken over to Manchester University's Electrical Engineering Department (some of the electronic panels and probably a teleprinter and power supplies).[70] The U.S. American counterpart, the special-purpose ballistic calculator ENIAC, was switched off in 1955 and taken apart, portions of it are on display at several locations on the continent.[71]

With the "Last of the Mohicans", Tom Kilburn and a few other electrical engineers directly involved in the development, the complete and living knowledge of an obsolete generation of automata, which can only be acquired by building them, died away, and with it, the possibility of obtaining details from them that were transferred informally and undocumented, either because they were presupposed as "common knowl-

66 The details can be found in S. Lavington, *A History of Manchester Computers* (Manchester, 1975).

67 Christopher P. Burton, Replicating the Manchester Baby. *Annals of the History of Computing* 27[3] (2005): 44–60, p. 44.

68 Cf. Brian Napper, Tom Kilburn (1921–2001), http://www.computer50.org/mark1/kilburn.html.

69 Material being re-used "cost nothing, and was known to work in a well-understood way so reduced learning time". C. P. Burton, personal communication, 8 March 2007.

70 Cf. B. Jack Copeland, A brief history of computing (The Turing Archive for the History of Computing, 2000, http://www.alanturing.net/turing_archive/pages/Reference%20Articles/BriefHistofComp.html): "Some of the electronic panels ended up at Newman's Computing Machine Laboratory in Manchester […], all trace of their original use having been removed." Campbell-Kelly, Programming the Mark I, p. 135: "The teleprinter equipment was acquired by Turing through contacts with the Foreign Office Department of Communications at Bletchley Park." Burton, Replicating the Baby, p. 53: "Indeed in 1948 Williams may have obtained [power] units indirectly from dismantled Colossi."

71 Parts are exhibited at the School of Engineering and Applied Science at the University of Pennsylvania, the National Museum of American History in Washington D. C., and elsewhere. Cf. Ulf Hashagen, ed., *History of Computing: Software Issues* (Berlin, 2002), p. 265.

edge" or because they were considered profane. When writing an emulator of the Ferranti Mark I to run Christopher Strachey's Love Letter Program from 1952, the author was unable to determine the functions of the buttons and switches on its user interface, because the available documentation did not cover them at all.[72] Fortunately, a retired computer scientist from Manchester University, Brian Napper, found "an engineer-biased description written in 1953 for ARE" (the Atomic Research Establishment) in his archive specifying their use.[73] At last, the durability of the paper on which the copies of the manuals circulate, and the interest of the owners in their conservation and their readiness at transcription determine the duration of survival of the remaining information and, hence, of the artefact itself.

The ingenious German computer pioneer Konrad Zuse (1910–1995), who invented the very first high-level programming language "Plankalkül" around 1945 and built several early machines, could also have served as an example of the "Last of the Mohicans" of an even earlier technical era.[74] The Z1 and Z2 from 1936 and 1939 used mechanical switches for storage and calculation, which moved metal pins into one of two positions. From 1940 to 1955 Zuse employed electro-mechanical relays (Z3, Z4, Z5, Z11). Already in 1937, his friend and fellow worker Helmut Schreyer, who wrote his dissertation about "tube relays" at the "Institut für Schwingungsforschung" (Institute for Oscillation Research) in Berlin under Wilhelm Stäblein, advised him to use thermionic valves, but Zuse considered it to be just "one of his wild ideas".[75] Since his developments were considered strategically unimportant by the German government, Zuse did not obtain the necessary funding and continued to use the mechanical switches and telephone relays, largely collected from discarded stock. Only in 1957 did the Zuse KG switch to vacuum tube technology and built the first computer on this basis, the Z22. All his early machines (Z1, Z2 and Z3) were destroyed during Allied bombardments.

72 Cf. Link, There must be an angel.

73 B. Napper, personal communication, 10 May 2006. Brian Napper sadly died in 2009.

74 The first published account of "Plankalkül", developed purely theoretically, dates from 1948: Konrad Zuse, Über den allgemeinen Plankalkül als Mittel zur Formulierung schematisch-kombinativer Aufgaben. *Archiv der Mathematik* 1[6] (1948): 441–449.

75 Cf. Helmut Schreyer, *Das Röhrenrelais und seine Schaltungstechnik* (Ph.D. diss., Technical University Berlin, 1941; online: http://www.zib.de/zuse/Inhalt/Texte/Chrono/40er/Html/0534/node1.html). K. Zuse, *The Computer — My Life* (Berlin, 1993), p. 38. Six years later in Great Britain, the engineer Thomas Flowers encountered a very similar reaction when he proposed to build a code-breaking machine from around 1,500 electron tubes – Colossus.

If machines only survive on paper, a general effect of abstraction can be observed, in which an increasing number of details is forgotten and material elements are sacrificed to the mysterious force of entropy. Full information is only stored in the artefact, as long as it is operational, and in the brains of its constructors, while they remember it. The intact apparatus is the shortest expression of its complexity.[76] Repairing it is therefore easier than understanding the mechanism completely, because only the functionality of the broken part needs to be reconstructed, while the rest of the knowledge is still implemented.

The surviving documentation can be divided roughly into several categories. The efforts of the next generation of electrical engineers in Manchester to resurrect the prototype computer, headed by Christopher P. Burton, serves to illustrate their usefulness and the information contained in them.

Apart from material remains, construction plans of parts or even of the whole machine would permit one to form a precise picture of the hardware. Unfortunately, these only very rarely exist for pioneering efforts, because they are developed experimentally, by modifying or exchanging components and by trying to tune them to a point where their consonance produces the desired results:

“The pioneers had no need for formal engineering drawings. Their working documents were a set of hand-drawn schematic circuit diagrams on a table (jokingly called Tom Kilburn’s office), in the corner of the laboratory, together with their personal notebooks. […] The machine was constantly being modified and added to, as were the diagrams that always represented the current state. Those circuit diagrams no longer exist, so we have had to rely on secondary sources”.[77]

Engineers sometimes set down valuable technical details in their notebooks, as an aid to memorise certain aspects of the work under construction. This was the case in the rebuild of the Manchester computer, which could rely on such sketches of Dai Edwards, Geoff Tootill, and Alec Robinson, who copied some of the diagrams on the table. Documentation often occurs when a transfer of knowledge is involved. In this case, the three research students were trying to catch up with the work underway.

Secondly, patent applications usually contain the technical specifications necessary to protect the intellectual property of the invention, but consciously exclude numerous details, like the exact models or values of the parts used (cf. Figure 13). They

76 Cf. Andrey N. Kolmogorov, Three approaches to the quantitative definition of information. *Problems of Information Transmission* 1[1] (1965): 1–7.

77 Burton, Replicating the Baby, p. 50.

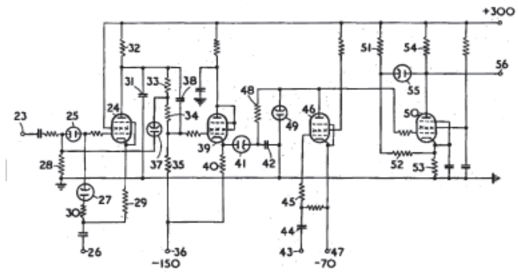

Fig. 13: Circuit diagram from the patent for Williams' storage tube, 1946.

depict the device in a general circuit diagram, and experimentation is required to actually build it. This "abstraction by concurrence" can be regarded as typical for the way an economic system based on competition prevents the dissemination of information. The transformation of the image part of patents from construction plans to circuit diagrams results from the idealisation of artefacts discussed earlier. Because the components look similar and do not reveal their functioning, which happens invisibly, the picture does not show the elements themselves, but represents their general function in abstract symbols: to switch current, to conduct it in only one direction, to resist, etc.

Thirdly, articles in journals on electrical engineering serve a similar purpose: to publish the results of research and to claim the priority of the invention publicly, not necessarily to enable others to build the apparatus (cf. Figure 14). They may still contain diagrams specifying more of the actual design, like the characteristic values of the components. Even if the engineers helped others to actually construct the artefact, the techni-

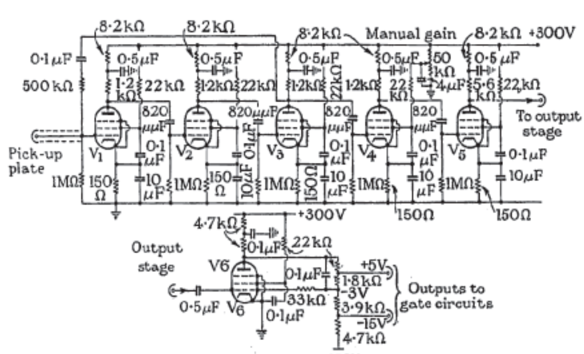

Fig. 14: Circuit diagram of the amplifier of the Williams tube from an engineering publication three years later.

cal details may have been communicated more informally, in letters or personal communication, and consequently might not have been preserved in written form at all.

After having acquired all surviving documentation and the original components, the struggle of the Baby rebuild project to make the Williams tubes they had constructed work, gives an impression of the effort required to turn the abstraction concrete again:

"Although the description of the CRT memory operation given elsewhere seems straightforward, as an analogue electronic device it was *tricky to adjust*. Controls for brilliance, focus, astigmatism, high-voltage supply, deflection voltages, amplifier gain, threshold level, dash width, dot width, and strobe pulse timing *all interacted*. The secondary emission behaviour of the screen phosphor is not uniform in the early tubes […] and furthermore they are susceptible to minute areas of zero emissivity, known as phoneys, where a bit cannot be stored."[78]

Fourthly, photographs might elucidate certain details that cannot be obtained elsewhere. In the case of the prototype reconstruction, photographs proved extremely useful, after they had been located: "The circuit diagram fragments [from the engineers' notebooks] and photographs were the key sources in our achieving authenticity." They made it possible to identify components that were not documented elsewhere, because they were not essential for the working of the machine, like the exact type of push-button switch used on the keyboard: "I spent many hours gazing at the original photograph through a jeweller's eyeglass […]. In one serendipitous moment, the pattern of holes on the panel suddenly brought to mind a set of five push-buttons that I had bought in 1953, and which I still had." Burton looked up the Royal Air Force part number in a catalogue, and finally found the exact component pictured on "a photograph of the Spitfire fighter's cockpit: It was a control box for the VHF radio."[79] Despite their idealisation and even as black boxes, the components possess a certain appearance that helps to tell them apart, even if their functionality can no longer be read off their surface.

Fifthly, manuals explained aspects of the machine to its future users to enable them to operate it.[80] They only contain the technical details necessary to understand its gen-

78 Burton, Replicating the Baby, p. 56 (Emphasis mine, DL). Burton goes on to explain that "*Phoney* is a sort of slang word used by World War II pilots meaning a radar echo that was not a real target. The term carried over to the SSEM [Small Scale Experimental Machine] team in 1948." The meaning was inverted from an erroneously displayed dot that represented nothing (a "radar angel", in other words) to a memory location that could not display a dot; cf. Link, There must be an angel, p. 37f.

79 Burton, Replicating the Baby, p. 51f.

80 These were only produced in Manchester after the prototype had evolved into a bigger machine; cf. Alan M. Turing, *Programmers' Handbook for the Manchester Electronic Computer Mark II* (112 page typescript, Manchester, 1951; online: http://www.turingarchive.org/browse.php/B/32).

eral functioning and do not permit it to be rebuilt. The engineering knowledge for its maintenance was usually transmitted by verbal instruction and training.

To be able to build a faithful replica of complex machinery, at least two types of documents are absolutely necessary. Diagrams of at least the most important subsections make it possible to reach an understanding of the logical functionality of the device. Photographs, on the other hand, permit determination of the physical properties of the components, their concrete type and location within the whole. They also show objects like racks, cables and switches which are not specified in a circuit diagram.

Given the fact that usually a lot of information that would be necessary is no longer available at the time the resurrection project is undertaken, the only means to fill in the gaps is by identifying with the engineers of the time, their technology and method of design, and by imagination, as indicated by Christopher P. Burton: "Lastly, by being immersed in the project I found it possible to 'think pioneer' and make plausible judgements as to what was correct."[81] Due to their interrelatedness, the information about the missing parts can be obtained from the remaining ones by deductive speculation, if somebody is willing to invest the time necessary to solve the puzzle. The situation corresponds to a rebus with known meaning in which one signifying element is missing and must be reconstructed. Although there are possibly several objects that can fill in the gap, their number is limited, especially in the advanced technology of an era. It might well be that sometimes this method is misleading, but unfortunately and in a number of cases, it is the only chance to complete the missing parts in the picture of an extinct artefact.

7. Inventions *in nuce*

Michael Thompson's *Rubbish Theory* is a witty study on the career of objects, which complements the linear arrows of economic theory pointing from the producer to the consumer with the idea of a cyclical return. He distinguishes three categories into which things fall in different moments of their history (cf. Figure 15). In the first one, transience, the commodity circulates on the market and its value decreases slightly over time. Two factors, fashion, which moves in cycles, and technology, which proceeds linearly, bring about a more radical drop in its price. The latter applies to singular components of a construction, as in the following example:

"[I]n the mid-eighteenth century, the owner of a new house in the City of London would find that his property gradually became obsolete […] [H]is plumbing system

81 C.P. Burton, personal communication, 8 March 2007. This kind of imagination is not to be confounded with free fantasy and association.

discharging into a cesspit in his rear basement room, whilst perfectly adequate when the house was new, would gradually appear less and less attractive after the invention in 1779 of Alexander Cummings's patent water closet […] [T]he march of technological evolution is irreversible and linear."[82]

While the water closet is still around today, 250 years later, more complex artefacts, especially in the early period after their invention, become obsolete and are replaced at a much faster pace, as demonstrated above. In a chapter aptly named "On the duration of machinery", Charles Babbage remarked in 1832: "During the great speculations in that trade [of making patent-net], the improvements succeeded each other so rapidly, that machines which had never been finished were abandoned in the hands of their makers, because new improvements had superseded their utility."[83]

When the commodity has become completely worthless, it enters a category considered covert by Thompson, that of rubbish. The object is suppressed and disappears from the consciousness of society. But astonishingly, at a certain point which is dependent on the end of its production, some artefacts resurface from the trash and are transferred to yet another category, durability. Eccentric evaluations by a few individuals lead to a renewed interest, enthusiasts start to collect them, and their value increases again. Finally, their price rises so high that they fall out of the market at its upper edge and are bought by museums, which reduce their relative speed in the stream of time to the smallest possible value.

This can be explained by the fact that its purposelessness turns obsolete technology from a complex means constructed by humans to achieve an end into a kind of natural beauty ("Naturschönheit", in German): "*Beauty* is an object's form of *purposiveness* insofar as it is perceived in the object *without the presentation of a purpose*."[84] Already before it is stopped, it can be interpreted aesthetically in this sense, because its inner workings — and thus the way in which it is realising its aim — is not easily understood by laypersons. The increasing disintegration of other copies of the same thing enhances the singularity and value of the remaining exemplars, and reverses the effects of Anders' "platonoidisation" (which, in eternalising its "idea", renders the concrete light bulb worthless) by fetishising the beautiful unicum.

Because Thompson takes artefacts as given and does not question how they come into existence, his theory does not treat another covert phase, in which they are first and foremost conceived, the experimental one, which precedes the overt state of transience. While belonging to this category, the material association is slightly altered, parts are replaced, optimised and tuned, until it delivers the desired performance.

82 Michael Thompson, *Rubbish Theory. The Creation and Destruction of Value* (Oxford, 1979), p. 38f.

83 Charles Babbage, *On the Economy of Machinery and Manufactures* (London, 1832), p. 286.

84 I. Kant, *Critique of Judgement* [1790], trans. Werner Pluhar (Indianapolis, 1987), p. 84.

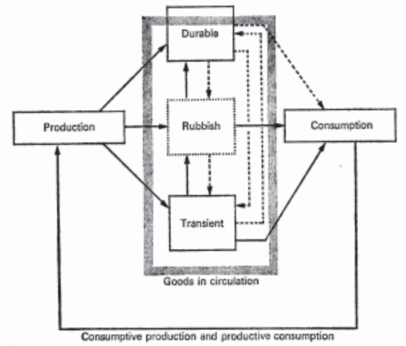

Fig. 15: Schematic view of Thompson's rubbish theory.[85]

Before this happens, it possesses the same enigmatic, Odradek-like appearance as the one that belongs to the rubbish. Being no longer and not yet useful results in the same type of object. And indeed, the specific form might have been adopted from an obsolete artefact, or even from a device invented for an impossible purpose, like perpetual motion or the communication with the dead. In a number of cases, an experimental setup is devised for a certain aim, but since the function it provides cannot be used by a wider public, it stays in the closed realm of the laboratory for a shorter or longer duration, sometimes even centuries, without ever entering the state of transience.[86] Or its effects are purely epistemic in that they challenge a current paradigm as anomaly and only have theoretical, but no immediate practical consequences.

By invalidating all attempts to understand Odradek as an obsolete artefact, Kafka ensures that the interpretations, which are always only partial, are ongoing. His riddle cannot be solved and, consequently, constitutes an enigma that survives. It is exactly this quality that Rheinberger takes as a condition for the durability of experimental systems, described aptly by Brian Rotman as "xenotext": "What [a xenotext] signifies is its capacity to further signify. Its value is determined by its ability to bring readings of itself into being. A xenotext thus has no ultimate 'meaning'".[87] Because Kafka's story can be understood differently forever, but never perfectly, it lives on. As long as forms of material association allow reinterpretation once their present purpose has become obsolete, they recur and are perpetuated. It is impossible to determine beforehand if a further fertile implementation is possible.[88]

85 Full lines indicate possible, dotted ones impossible transfers. Thompson, *Rubbish Theory*, p. 113.

86 An example of this are letter wheels. After Alberti had established that they could be used as cryptographic devices in 1467, it took more than 450 years until the military employed them in this way; cf. D. Link, Scrambling T-R-U-T-H, in: *Variantology 4*, eds. S. Zielinski and Eckhard Fürlus (Cologne, 2010), pp. 215–266, here p. 262f.

87 Rheinberger, *History of Epistemic Things*, p. 36f.

The process of "poietic" engineering employed to reach a new understanding of the setup is similar to innovative processes in language. A word combines elements from one class, the alphabet, for the purpose of conveying meaning, and in ordinary usage, convention prescribes which letters to use. The primary goal attained is symbolic, but would not be effective without imaginary (world reference) and real (contract, instruction etc.) consequences. Avant-garde poets create new significations by trying out new combinations of letters and words. The artefact, on the other hand, employs material elements from different classes (glass, air pump, electricity in the case of the light bulb) to achieve immediate material goals at first, but later also imaginary and symbolic ones (media, algorithmic machinery). The situation of designing an experimental setup corresponds to the free construction of a rebus for a given meaning. Forms need to be selected that are known to perform a certain function and must be combined in the right way. The number of possibilities is high to begin with but reduced by reasoning and experiment. Similar to poets, scientists challenge conventional implementations by modifying the material association to see if new effects arise.

The processes of replacing and tuning parts to make the *bricolage* work in the desired way can be compared to the operations of metaphor and metonymy in language. They exchange components or adjust certain parameters, but only slowly transform the formal core of the artefact. Rheinberger writes: "Science, viewed from a semiotic perspective, does not escape the constitutive texture of the inner workings of any symbol system: metaphoricity and metonymicity. Its activity consists in producing, in a space of representation, material metaphors and metonymies."[89] Poets are constrained in their innovative combinatorics by the linguistic conventions of society that secures understanding, and inventors and scientists by the laws of nature: "We have to recognise that the qualities objects have are conferred upon them by society itself and that nature […] plays only the supporting and negative role of rejecting those qualities that happen to be physically impossible."[90]

Certain transfers are theoretically ruled out by Thompson. An object cannot move from rubbish to transient or from durable to transient under normal circumstances governed by the laws of the market. The first one, he concedes, occurs "to a limited degree, which does not seriously threaten the boundary maintenance, in the business affairs of the dealer" and is "implicit in the slogans 'we want what you don't' and 'houses cleared free of charge'."[92] He similarly shows that the second one only takes place in

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88 In parallel to Thompson's "father of all the Tiv", Odradek could be called the forgotten ancestor of all artefacts; Thompson, *Rubbish Theory*, pp. 65–69.

89 Rheinberger, Experimental systems, p. 114f.

90 Thompson, *Rubbish Theory*, p. 9.

91 Full lines indicate material, dotted ones immaterial transfers.

92 Thompson, *Rubbish Theory*, p. 106.

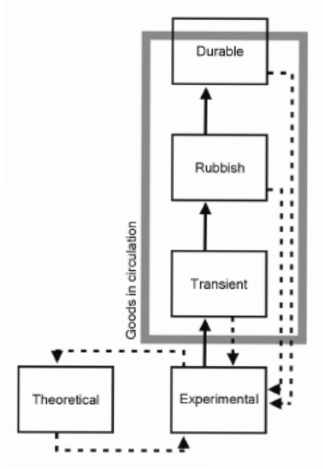

Fig. 16: A cyclical extension of Thompson's rubbish theory.[91]

troubled times by quoting the example of wartime privations in Germany "that caused the (regretted) exchange of Old Masters for tins of corned beef".[93] In the construction of the artefact precisely these transfers happen on an immaterial level (cf. Figure 16).

The experimental phase reintegrates the outcome of earlier cycles. The components of the "machines for making the future"[94] can be of natural descent, like the bamboo filament of early light bulbs, but they usually result from prior inventions, like the vacuum tube. The transfer takes place from the transient category back into new, tentative systems. Techniques of associating and shaping components, technical schemata, can be extracted from museological or almost forgotten devices and be transcribed to new, tinkered constellations. And it is the effects of artefacts as anomalies in basic research, changes of paradigms, which open up the possibility to invent new, vague ideas of purposes and their implementation. The transfer from rubbish or durable back to experimental and later transient transcends the demarcation lines between the categories postulated by Thompson. The "communicable things"[95] are transacted at each station of their life cycle, even if they no longer change their physical location, be it the rubbish dump or the museum.

The fact that epoch-making inventions started their life cycle as Odradeks, abstruse and purposeless creatures, which were sometimes doomed from the beginning, is a strong argument against forcing all research in science to be of an applied nature. This would have prevented the creation and transformation of absolutely useless artefacts that in the past led to important and far-reaching discoveries.

93 Thompson, *Rubbish Theory*, p. 107.

94 Rheinberger, Experimental systems, p. 110.

95 Thompson, *Rubbish Theory*, p. 44.

To raise some issues concerning algorithmic objects in particular, the last section discusses a case of crypto-history: the German Enigma and its decipherment by Polish mathematicians before and during the Second World War.[96]

8. The Archaeology of Algorithmic Artefacts

If algorithmic machinery is described without experimenting with it, there is a danger of adulteration, even if the methodology employed is scientifically impeccable and the author's background knowledge very extensive.

On the first pages of *Seizing the Enigma*, the cryptohistorian David Kahn describes the *éthos* of his research: "The book […] focuses upon personalities and rests as much as possible upon primary sources, namely documents and interviews." Kahn decided to include the technical details in his text: "This material [on Enigma cryptanalysis] may seem dry, but to leave it out would obscure a main point of this book: the fearful difficulty of the work of the cryptanalysts".[97] Because of the tactical relevance of the intelligence obtained, which played a role as important as the findings by radar and other technical advances, any account omitting the hidden cryptographic battle would be incomplete. The official historian of the British Crown, Harry Hinsley, estimated that the breaking of Enigma shortened the war by at least two years.[98] Given the prevalence of myths and cover stories concerning the events of World War II, it seems even more important than with other topics to rely as much as possible upon primary sources.

In *The Codebreakers*, Kahn gives an extensive and historically rich overview of cryptological technology throughout the centuries, and it is difficult to name any other author who possesses a comparably intimate knowledge of the field. However, when it comes to the first machines built by the Poles and the procedures executed on them, despite his cautious methodology, the book strangely teems with errors. Concerning the cyclometer, one of the earliest devices, Kahn writes: "The maximum of 26 [letters] was reached in only three ways, or cycles: two chains of 13; six chains of 10, 10, 2, 2, 1, and 1 letters each; and six chains of 9, 9, 3, 3, 1, and 1 letters each."[99] If this had been the case, the apparatus would have been useless, because it would not have reduced the

96 For the following see D. Link, Resurrecting bomba kryptologiczna: Archaeology of algorithmic artefacts, I. *Cryptologia* 33[2] (2009): 166–182.

97 David Kahn, *Seizing the Enigma. The Race to Break the German U-Boat Codes*, 1939–1943 [1991] (London, 1992), p. X.

98 B. Jack Copeland, Enigma, in: B.J. Copeland, ed.: *The Essential Turing: Seminal Writings in Computing, Logic, Philosophy, Artificial Intelligence, and Artificial Life* (Oxford, 2004), pp. 217–264, p. 218.

99 Kahn, *Seizing the Enigma*, p. 63.

number of combinatorial possibilities to a manageable level. Actually, 82 different characteristic patterns exist.[100] A later machine, the "bomba kryptologiczna", is described in the following way (cf. Figure 17):

"[The Polish cryptologist] Rejewski soon found a way of determining the keys when the indicators in three messages fulfilled certain conditions. [...] One pair [of the three pairs of Enigmas incorporated into the bomba] would be testing the indicators of messages 1 and 2, another those of messages 1 and 3, and the third those of messages 2 and 3."[101]

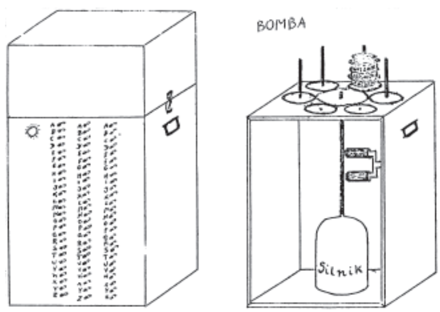

Fig. 17: Sketch of Polish "bomba" by Rejewski, 1976 (Johnson 1978, p. 316).

This is all the more astonishing since Kahn could rely on the descriptions, and especially the appendixes, in the English translation of Kozaczuk's very detailed and precise book, which clearly detail that each pair was simply working on one female indicator received.[102] It shows, and this is the only purpose of the two examples quoted, that one cannot understand, describe, or research these devices without experimenting practically with them, either by rebuilding them or by simulating them in software.[103] Turing's statement that "[i]t is possible to produce the effect of a computing machine by writing

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100 The author has programmed a simulator of the cyclometer, which can be found at http://www.alpha60.de/research/bomba_krypt/. It has been calculated that theoretically, 101 patterns are possible; cf. Kris Gaj and Arkadiusz Orłowski, Facts and myths of Enigma. Breaking stereotypes. *Eurocrypt 2003*: 106–122, p. 113.

101 Kahn, *Seizing the Enigma*, p. 73.

102 Marian Rejewski, Jak matematycy polscy rozszyfrowali Enigm ("How Polish mathematicians broke the Enigma cipher"). *Wiadomo ci Matematyczne* 23[1] (1980): 1–28. English translation: How the Polish mathematicians broke Enigma, Appendix D in: Władysław Kozaczuk, *Enigma: How the German Machine Cipher Was Broken, and How It Was Read by the Allies in World War Two*, trans. Christopher Kasparek (Frederick, MD, 1984), pp. 246–271, p. 266f.

103 Kahn's book contains a wealth of details that are not found in other accounts and therefore remains an excellent historical survey on the topic.

down a set of rules of procedure and asking a man to carry them out", his concept of a "paper machine", is theoretically and practically true for Enigma, but only theoretically (under the condition of almost eternal time) for the cyclometer and the bomba. The only reason these apparatuses were built is that it was no longer possible to perform the corresponding routines with "paper, pencil and rubber, and subject to strict discipline".[104] The concrete details of their functioning cannot be captured in descriptions, and even if there was a complete one, it would be impossible to grasp it without putting it into practice.

That these devices execute procedures that are too lengthy and complicated for humans to perform radically reinforces Kant's dictum that "we have complete insight only into what we can ourselves make and accomplish according to concepts."[105] Not incidentally, the mixing of theory and practice is already typical for the cryptanalyst's work. Rejewski wrote about the invention of the bomba and the Zygalski sheets: "Yet, within a very short time […] we had two ideas, or rather, what was more important, we found ways to realise those ideas."[106] The historian or any other scholar trying to depict the developments suddenly finds himself in the same situation as the codebreakers. To verify the claims of different parties in the event and to really grasp these devices, one needs to be able to perform the procedures that have been employed.

It may seem that the title "computer history" is better suited to designate the investigation of algorithmic artefacts of bygone days. However, there are several arguments why the concept of archaeology should be preferred.

Because of the irrelevance, exchangeability, and opaqueness of their components, symbolic machinery moves with higher speed in the stream of time, quickly becomes obsolete and is obliterated even faster. The language that is coupled to it to control it, like in Enigma, creates a new field in the usage of signs. After a very long time, the question of how to achieve certain effects through symbols could be posed in a different way. Unlike natural expressions, their complete arbitrariness is not conserved by collective tradition. In the proliferation of programming languages, which is a reaction to the ongoing software crisis, ways of formulating change in rapid succession and are forgotten.[107] The text in which Robert Recorde introduced the equal sign 450 years ago is understood today without much effort: "And to auoide the tediouse repetition of these woordes: is equalle

104 A.M. Turing, Intelligent machinery (22 page typescript, report to the National Physical Laboratory, 1948; online: http://www.cs.usfca.edu/www.AlanTuring.net/turing_archive/archive/l/l32/L32-001.html), p. 5. The paper was first published 20 years later, in: Christopher R. Evans and Anthony D.J. Robertson, eds., *Cybernetics: Key Papers* (London, 1968), pp. 27–52.

105 Kant, *Critique of Judgement*, p. 264.

106 Rejewski, How the Polish mathematicians, p. 266.

107 Jean E. Sammet estimated in 1991 that over 1000 programming languages had been created in the USA alone since 1953. Only few of them have survived to the present day; cf. J.E. Sammet, Some approaches to, and illustrations of, programming language history. *Annals of the History of Computing* 13[1] (1991): 33–50, p. 48.

to: I will sette as I doe often in woorke vse, a paire of parralles, or Gemowe lines of one lengthe, thus: ==, bicause noe. 2. thynges, can be moare equalle."[108] This does not apply to the words that caused the Manchester Mark I to compose love letters 45 years ago, even for programmers: "//I/ //ZO ZA/: DEQO AIQB RE/: S:LO DSWO IST/ …"[109] Archaeology investigates buried, incomplete, and often enigmatic artefacts.

The study of algorithmic apparatuses opens up a terrain in which theoretical and practical aspects, immaterial procedures and their technical implementation refer to and emerge from each other. The *difference of execution*, which separates them from other artefacts and consists in their autonomous carrying out of almost endless sequences of instructions, creates an opaque area between the input of the original data and the incalculable moment in which the machine returns with the result, which is not easily penetrated. The history of technical ideas cannot omit this space of time and like cryptology is plunged into the question: What exactly is executed here? The theoretical investigation is forced to pass through the practical work of reconstructing the apparatus and the operations performed on it. Not to proceed in this way would only leave the possibility of hermeneutically interpreting cryptograms based on their mere appearance, as Dadaist poems. The mixing of narration and practical reconstruction, of confirmed fragments and deducto-speculative complements is likewise typical for archaeology.

The display and output of an algorithm is a surface without obligation. The symbols that instruct the procedures can indeed be found in the source code. However, because of the executive difference, their reading can just result in a complete picture of the operations in the case of very simple algorithms. Only the execution unfolds the complexity implemented in them and allows the formulation of reliable propositions about processes that cannot be described or run on paper for principal and for practical reasons. The authoring of experimental software becomes part of the theoretical investigation, because it is the only way algorithmic artefacts can be fully and concretely grasped.

Michel Foucault's *Archaeology of Knowledge* aimed at localising *dispositifs*, objective symbolic structures whose effectiveness was apparent through the multitude of concrete phenomena like regulations, truths, architectures, etc. that they generated, comparable in principle to the workings of the Hegelian *Weltgeist* (world spirit).[110] The more the humans that constitute the *Weltgeist* achieve their aims through instruments, investigate reality with apparatuses, and change it through material associations, the more the history of ideas is forced into matter. The archaeology of algorithmic artefacts endeavours to reconstruct from objective technical forms the theoretical currents that generated them and were generated by them.

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108 "Gemowe" means "twin", compare "Gemini"; Robert Recorde, *Whetstone of Witte* (London, 1557), quoted in Florian Cajori, *A History of Mathematical Notations. Vol. 1: Notations in Elementary Mathematics* [1928] (New York, 1993), p. 165.

109 Cf. Link, There must be an angel.

110 Michel Foucault, *The Archaeology of Knowledge* [1969], trans. A.M. Sheridan Smith (London, 1972).

It is a pity that the Polish bomba never found its way onto Italian soil. Some ingenious owner of a latteria might have discovered that the construction with its planetary gear and six mixers was even better suited to whipping cream than a motor from a smashed-up motorbike, and might have adopted it, thereby making the strange legends entwined around the device come full circle.

9. Postscriptum

One of the most enlightening interpretations of Odradek says that its name is an incomplete anagram of Greek "dodeka(ed)r(on)", one of the five perfectly regular Platonic solids.[111] This proposal can be slightly extended. Apart from the metaphysical speculations of Kepler, this figure does not play any practical role in the sciences, for example, in crystallography. Yet almost one hundred so-called "Roman dodecahedra" from the second to fourth century CE made of brass have been found within the borders of the former Roman Empire, from England to Hungary and the east of Italy, but most of them in Germany and France (cf. Figure 18): "They are hollow with circular holes of differing sizes in the faces and with knobs at their vertices."[112] First specimens were already described in 1896. The function of these objects is completely unknown to the present day; none of the various hypotheses has been confirmed and most are held to be refuted.[113]

Fig. 18: Roman dodecahedron.

111 Cf. Jean-Claude Milner, Odradek, la bobine de scandale. *Elucidation* 10 (2004): 93–96.

112 Benno Artmann, Roman Dodecahedra. *The Mathematical Intelligencer* 15[2] (1993): 52–53.

113 The objects in Figure 10 are a Geissler tube magnetic motor, France, 1870, an electromagnetically contracting helix, Daniel Davis, 1848, and an unusual electric motor, England, 1860. John D. Jenkins generously provided the high-resolution images.