Modes of Manifold Writing

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A text on the polygraph, written for the Literature-Technology-Media website, University of Cambridge.

In its relation to words like 'copious' and 'cornucopia', the word 'copy' still harbours the suggestion of spilling abundance. But the almost demonic ease in which copies – of texts, images, objects, melodies – may now be made and archived forms a sharp contrast with the considerable application of labour, whether in the scriptorium or the artist's studio, that the production of copies has required in previous centuries. Just as the pyramids could not have been built without the muscle-power of slaves, so the huge expansion of government and private bureaucracy from the early nineteenth century onwards demanded and itself reproduced a huge army of clerks who toiled at the work of making and keeping copies of documents, giving rise to ailments like 'scrivener's palsy'. During the nineteenth century, the figure of the clerk haunts the writer as his spectral parody, in a tradition that runs through Melville, Dickens and Kafka through to Truman Capote's remark about Jack Kerouac that 'that's not writing, that's typing'. This tradition is inaugurated perhaps by 'The Superannuated Man' in 1825, (Lamb 2003, 64- 70), in which Charles Lamb describes the emancipation of a man who has spent decades copying others' words – like Lamb himself, who worked in the Accountant's Office of the British East India Company for 36 years.

The most familiar form of automated textual reproduction at the beginning of the nineteenth century was, of course the printing press, but this offered economies in reproduction time only on large scale. These economies became available in the home and office for the first time in the form of the carbon copy, patented by Ralph Wedgewood in 1806 as part of the apparatus he called a 'Stylographic Writer'. This would be the principal method for copying documents, especially those produced by the typewriter from the 1870s, for more than a century, until the arrival of automated copying technologies after the Second World War. The polygraph was briefly a rival to carbon paper in what a writer of 1807 called the 'modes of Manifold writing' (Lyman 1807).

The principles of the polygraph were established in devices developed for the copying not of written documents but rather of images and plans. The first of these, known as a pantograph, was developed by Christoph Scheiner in 1603, and described in his *Pantographice seu Ars delineandi res quaslibet per parallelogrammum lineare seu cavum* (1631). In this, a stylus was connected by an adjustable parallelogram to a pencil; when the stylus was moved around the outlines of an image, the pencil produced a replica image on another surface. One conspicuous advantage of the pantograph over a one-to-one tracing was that adjustment of the angle of compression of the mediating parallelogram allowed for adjustments of scale in the copy. In a sense the pantograph provides nothing more than a displaced tracing, though the principle is still at work in a large number of processes that employ one-to-one mimicry of analogue movements: including the automatic copying of phonograph records, remote-control devices of all kinds, motion capture in cinema and even the operations of the computer mouse (I remember having to explain to a new computer user in the 1990s that 'moving the mouse around the screen' did not require holding it up to the glass).

The pantograph was adapted to the copying of handwriting in a patent applied for in 1647 for by the young William Petty, founder member of the Royal Society and later a developer of

the science of 'political arithmetic', and also, very likely, a spy in the service of Charles I. Petty's application made reference to 'an Instrument of small bulk and price, easily made, and very durable, whereby one may in an houres practice, write two Copies of the same thing at once, with great advantage above the ordinary way' (Petty 1648, n.p.), though alas he did not describe it in any detail nor provide an illustration. In 1762, the Count Leopold von Niepperburg of Vienna developed a handwriting-duplication machine that allowed two or three copies to be made simultaneously (Wershler-Henry 2005, 36). In 1783-4, a device named the 'physiognotrace' was invented by Gilles-Louis Chrétien, which allowed one to make a copy of an outline drawn round a silhouette. In 1799 Marc Isambard Brunel was granted patents in America and Britain for '*a certain new and useful Writing and Drawing Machine, by which two or more Writings or Drawings, resembling each other, may be made by the same Person at the same Time*' (Anon 1800, 153). An American patent was granted four years later to a similar device made by John Isaac Hawkins, who worked to develop it with Charles Willson Peale, an artist, inventor and director of the American Museum in Philadelphia. Hawkins used the principle of the physiognotrace to construct a polygraph, or machine for simultaneous duplication of writing, for which he sold the American rights to Peale before returning to his native England.

The most well-known and enthusiastic user of the Hawkins-Peale polygraph was Thomas Jefferson, who served two terms as US President from 1801-9. Jefferson not only used the machine for over 20 years until his death in 1826, producing almost 20,000 copies of letters, he also engaged in extended correspondence with Peale about the maintenance and improvement of the device. Jefferson's letters to Peale are themselves an autographic phenomenon, worthy of an illustration by Escher. The polygraph is both subject and object of the writing, as letter after letter, inscribed using the device, grapples with the irritations and inconveniences of its design and proposes alternatives. Jefferson often resorts to sketches of the improved versions of the machine he has in mind, and uses his letters to explicate the models he had constructed by his own workmen to embody his own ideas for improvement. The polygraph is a machine in the making, writing going hand in glove with wrighting. Like the self-evolving 'knitting machine' of evolution that Joseph Conrad would evoke in a letter of 1897, that 'has made itself without thought' (Conrad 1983, 425), the Jefferson-Peale polygraph was autobiographically employed in writing out its own form, or rather forms, for these were plural, including different designs, portable and desk versions, and even an octavo version made in 1804 for the duplication of ladies' notes. Much of his polygraphically-produced correspondence with Peale is taken up with planning and plotting the movements of these various machines, by land and sea, between Philadelphia, Washington and Virginia.

Though the principle of the polygraph was extremely simple in practice it proved fiendishly difficult to produce a mechanism that could reliably transmit all the subtle variations of speed, pressure and rapid fluctuations of lifting and resumption involved in handwriting, and maintain the perfectly flat writing surface required for successful transcription: Jefferson wrote in 1806 that 'I have safely received my Polygraph, with which I am now writing, and find it to answer well everywhere except a small place in the N. W. corner' (Sellers 1904, 309). Not the least of the difficulties with which Jefferson and Peale grappled was the synchronisation of the inkwell-dipping required to keep the traditional quills favoured by Jefferson charged with ink. If 'organically coherent handwriting' was, as Friedrich Kittler has argued, at the centre of the 'discourse network' of 1800, as the means whereby the soul could inscribe itself directly on to the page (Kittler 1990, 82), then this kind

of *Aufschreibesystem*, or 'writing-down system', the phrase of Daniel Paul Schreber which 'discourse network' rather distantly renders, is not so much the ghost in the machine as the machine at the ghost-writer's fingertips.

The polygraph was in every sense a technographic manifestation. For all its tricky, infuriating, fascinating materiality, perhaps the polygraph was always going to exist more fully in graphic than material form. And indeed, even the continued sponsorship and earnest endorsement of the US President, who called it 'the finest invention of the present age' (Bedini 1984, 147), was not enough to build a significant market for the polygraph. Peale only ever sold 60, and even John Hawkins, who got up to 150 sales in Britain (Bedini 1984, 187) made little impact. Only two complete polygraphs remain in existence, one in Jefferson's Monticello house, the other in the Franklin Institute in Philadelphia, and the latter seems also to have been owned by Jefferson (Bedini 1984, 183). This may have been in part because of the competition represented by versions of James Watt's method of taking copies instantly by means of special papers and inks combined with a press, or Ralph Wedgewood's 'stylograph', system incorporating 'carbonated paper', patented in 1806. Jefferson was convinced that Wedgewood's messy system would never rival the polygraph, writing to Peale in 1807 that '[f]urther trial of the Stylograph convinces me it can never take the place of the Polygraph but with travelers, as it is so much more portable. The fetid smell of the copying paper would render a room pestiferous if filled with presses of such papers' (Sellers 1904, 312).

The failure of the polygraph to be widely adopted, even in government offices, may also have been because of the very feature of the polygraph that made Jefferson so devoted to it, namely that it required such constant, vigilant attention to its workings and maintenance. Jefferson reassured Edward Preble, in a letter accompanying a gift of a polygraph of 1805, that '[y]our turn for mechanics will render pleasing to you those little attentions necessary in the use of the instrument' (quoted, Bedini 1984, 119). But not every user had the same turn for mechanics as the gadgeteer President, who alternated his reflections on the polygraph with discussions of ploughing techniques and inventions, interleaving page and *pagus* (Sellers 1904, 404-5). The more Peale and Jefferson toiled together to perfect the fiddly and capricious machine, the more Peale's advertisements assured customers of its simplicity and reliability, promising that '[t]he merit of the Machinery consists in its extreme simplicity, and therefore requiring [sic] little care to keep in order' (quoted, Bedini 1984, 152), and that the device could be operated by the 'feeblest female hand' (quoted, Bedini 1984, 99).

Perhaps, from the point of view of the tinker-addicted Jefferson, the very sensitivity and capriciousness of the machine was a proof of its fitness for the delicate task of ensuring that 'obedient pens in concert move', as a versified advertisement by Peale's son Rembrandt declared in 1804 (quoted, Bedini 1984, 82). Jefferson lived and worked so long hand in hand with the polygraph that it seemed to shadow his own aging and ailments. In 1822, he wrote that 'after 12 or 14 years of hard service it has failed in nothing except the spiral springs of silver wire which suspend the pen frame. These are all but disabled, and my fingers are too clumsy to venture to rectify them, were they susceptible of it' (Sellers 1904, 414-5). 3 years later, in 1825, Jefferson again had occasion to notice the coupled caducity of machine and operator:

> The excellent Polygraph you furnished me with 16 or 18 years ago has continued to perform its functions well till within a 12 month past. By the mere wearing of its

> joints, as I suppose, it became at last so rickety that I was obliged to give it up; and believing nobody but yourself could put it to rights, I have held it up for a safe hand to whom I could trust its transportation to you. (Sellers 1904, 417-18)

The word 'polygraph' underwent the same oscillations between operator and mechanism as later words like 'typewriter' and 'computer'. The word 'polygraphus' was adapted from Latin to mean 'one that has wrote many Books, one that writes much' (Arrol 1750, 297). In a letter of 1791, Friedrich von Matthisson compared the choice output of Thomas Gray favourably to that of 'the Polygraph of Ferney [Voltaire] with his seventy volumes' (Matthisson 1799, 208). By the 1790s, the idea of a device that would create an exact facsimile had led to the common usage of the word 'polygraph' to mean a mimic or physical double of a person. Coleridge uses the word in this sense in a letter of December 1794 to Robert Southey, in which he remarks, of a sonnet of his own in praise of Sheridan, '[t]he mode of bepraising a man by enumerating the beauties of his Polygraph is at least an original one' (Coleridge 2000, I.141) . In Hannah Cowley's 1795 play *The Town Before You*, a character boasts that he has been able to dine regularly on the strength of his likeness to Lord Beechgrove, and his interlocutor agrees that '[t]he resemblance is astonishing – they call you his polygraph' (Cowley 1795, 18). In Mary Robinson's novel *Walsingham* (1797), the young Lord Kencarth boats of having two polygraphs, explaining that this means 'a fellow that apes one's dress and manners as close as one's shadow: one that is up to all our gossip; is sick, lame, blind, gay, grave, in and out of condition, in imitation of his prototype' (Robinson 1797, 10).

After the polygraph fell out of use, or perhaps because it never really fell into it, the unemployed word was requisitioned during the nineteenth century to describe other kinds of automated transcription. The polygraph had reproduced not just the words consciously framed by the writer, but also the bodily form or event of that framing, complete with all the signs of deliberation, agitation or haste. As Hillel Schwartz writes, '[t]he polygraph made of the human body itself a working model of fair, accurate, indelible transcription' (Schwartz 2014, 189). In not only duplicating content, but also transcribing gesture and performance, the polygraph anticipated the power of the telephone to bundle up the contingent textures of intonation with the import of an utterance. The nervous twitches and scribbles of the polygraph trace out a kind of visual auscultation, as alive to all the forms of gestural noise in the life of the body as the telephone, phonograph and microphone were to all the noisy accidents of the breath and voice. It was this capacity of the polygraph to convey the 'signatures' of bodily processes that led during the 1870s to the adoption of the word 'polygraph' for devices that recorded traces of different bodily functions. The name proved adaptable to these new systems not because they produced multiple copies of the same message, but because they allowed for the graphing and collation of several different streams of bodily information simultaneously – pulse, respiration, blood-pressure, skin-conductivity. The lie-detecting polygraph was developed for forensic use by John August Larson in 1921, though names like the 'emotograph' and 'respondograph' were tried out by rivals (Alder 2007, 80). Larson himself proposed to call his machine the 'cardio-pneumo-psychogram' (Larson 1922). The lie-detecting polygraph disjoins the voluntary from the involuntary writing of the dissimulator. This new use of the word reactivated an earlier association of the word 'polygraph' with coded or secret messages, especially in the manual of cryptographic method entitled *Polygraphiae* published by the German occultist Johannes Trithemius in 1518. A technology designed obediently to mirror the self-knowing and self-inscribing subject, ensuring a kind of scriptive self-possession, becomes an instrument for registering the subject's polygraphic plurality.

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The course covers manifolds and dierential forms for an audience of undergrad-. uates who have taken a typical calculus sequence at a North American university, including basic linear algebra and multivariable calculus up to the integral theo-. rems of Green, Gauss and Stokes. With a view to the fact that vector spaces are. nowadays a standard item on the undergraduate menu, the text is not restricted to. curves and surfaces in three-dimensional space, but treats manifolds of arbitrary. dimension. Some prerequisites are briey reviewed within the text and in appen and Stiefel manifolds that naturally use the geometry of these manifolds. In the special cases that we are aware of, our general algorithms are competitive up to small constant factors with the best known special algorithms. Conjugate gradient and Newton on the Grassmann manifold have never been explicitly studied before.Â We shall benet from two dierent yet equivalent modes of describing our spaces: concrete representations and quotient space representations. Table 2.2 illustrates how we store elements of Vn, p and Gn, p in a computer.Â most dierential geometry books, the equation of motion for geodesics is written in. intrinsic coordinates in terms of so-called Christoel symbols which specify a quadratic form of the tangent vectors.