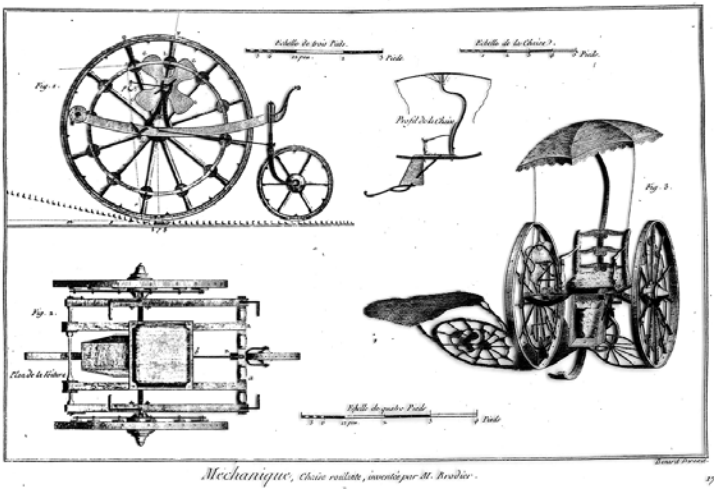
4.

What Led to the Invention of the Early Bicycle?

Hans-Erhard Lessing

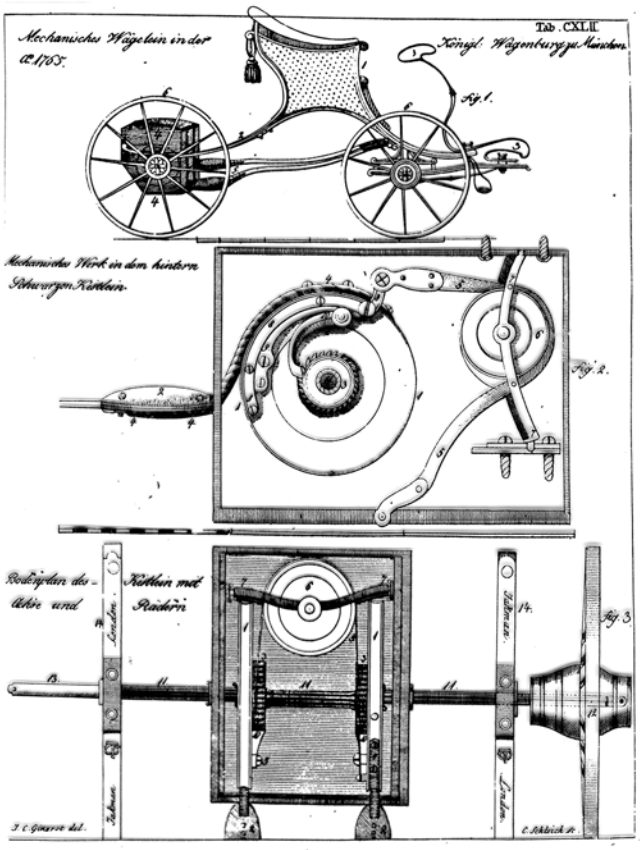
This paper tries to reconstruct the sequence of events leading to the invention of the two-wheeler. Close examination of the sources relating to the precursor of the bicycle, von Drais' four-wheeled Fahrmaschine (Driving Machine), reveals that he actually built two different prototypes. Their reconstruction has to be attempted only from descriptions of them, since no pictures exist. These experimental vehicles were the result of a critique of existing treadle-powered garden phaetons.

Wheelchair from Diderot's Encyclopédie 1751/80
...such a machine could be of use to mankind only, if it would be designed for handicapped persons or those without legs, which would then require a hand crank
(experts v. Tulla and Weinbrenner 1814)



Drais' interest had turned to land locomotion in 1812 when a famine severely affected the area where he lived and continued until its climax in 1816, "the year without a summer." How he arrived thereafter at his Laufmaschine (Running Machine), with two wheels in line that needed to be balanced, can only be answered with an educated guess. One factor was certainly ice-skating, with which riding the two-wheeler was compared by contemporaries. Another factor was the

Fig. 0401. Opportunities for human power: wheelchair from Diderot's **Encyclopédie,** 1751–1780. "… such a machine could be of use to mankind only if it would be designed for handicapped persons or those without legs, which would then require a hand crank" (excerpts from Tunlla and Weinbrenner in Ref. 2, 1814).



Garden Phaeton of 1765 (Jackman,London)
There have been earlier attempts to self-propel a carriage via some machinery. But that machinery was ponderous in surmounting friction, complicated, and therefore never suitable for a noticeably practical use (Drais 1813)

Fig. 0402. Garden Phaeton of 1765, Jackman, London (from Ref. 3). "There have been earlier attempts to self-propel a carriage via some machinery, but that machinery was ponderous in surmounting friction, complicated, and therefore never suitable for significant practical use."

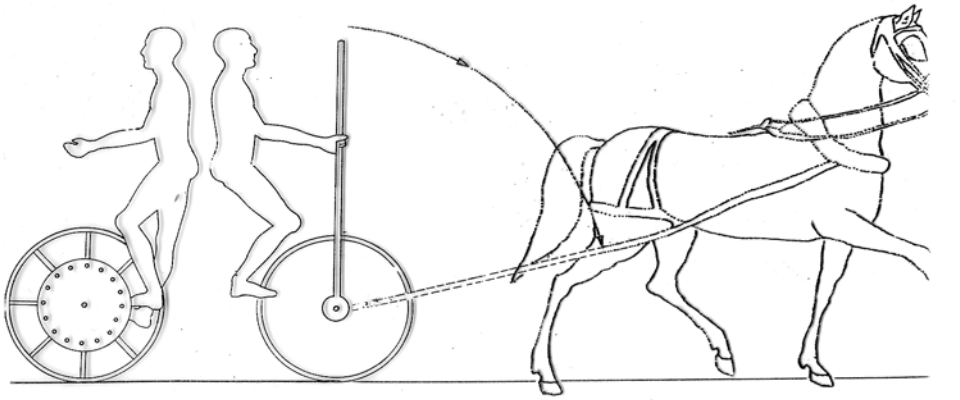
Chinese wheel-barrow reported earlier by a Dutch expedition in the very magazine in which Drais later published his second driving machine.

Design and engineering aspects of the history of the bicycle are often largely underestimated, because from hindsight the problems the developers had appear negligible. For instance, there were no extensive experiences on how to move a carriage by acting on its wheels at the end of the 18th and the beginning of the 19th century. Carriages or carts were either pulled or pushed by animal or human power, with the wheels revolving passively. The huge impediment against human-powered vehicles was of course that in a horse civilization the upper classes did not want to appear in public labouring themselves for their locomotion. This snobbish attitude is still at work today to limit general bicycle usage in our motorized society.

Yet two exceptions to that rule existed then:

1. Vehicles for the handicapped. See Fig. 0401, which shows an example from Diderot's Encyclopaedie.[1] Its hand cranks turned the large wheels through a clover-shaped gear. Interestingly enough, the experts[2] judging Drais' first application for a Badenian privilege for his Driving Machine argued exactly in that vein: "Such a machine could be of use to mankind only if it would be designed for handicapped persons or those without legs, which would then require a hand crank."

2. Garden vehicles, like the garden phaeton[3] in Fig. 0402, used in castle gardens. Here the use of human- instead of horse-power was presumably to



Drais' Driving Machine I of 1813
...consists of a 4-wheeled cabriolet-type wagon within which a man can move the axle plus the rear wheels by treading around a wheel with his feet (privilege experts 1814)
Arriving at steep hills or too bad a road one takes a horse as an extra team - like wagoners do - by letting down the direction rods ... to become shafts (Drais 1814)
In Summer 1814 to Vienna (via Danube?)and back = 1000 miles

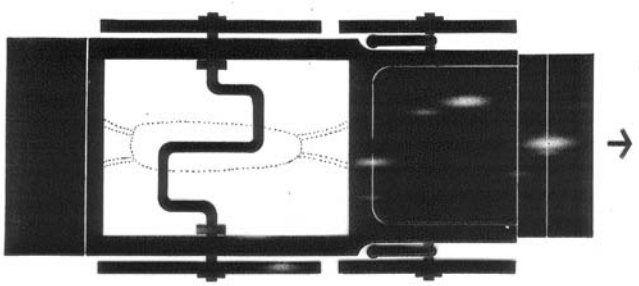
Fig. 0403. Drais' driving machine No. 1 of 1813 (reconstruction from Ref. 2) "...consists of a 4-wheeled cabriolet-type wagon within which a man can move the axle and the rear wheels by treading around a wheel with his feet." According to Drais, Ref. 8: "Arriving at steep hills or too bad a road, one takes a horse as an extra team — like wagoners do — by letting down the direction rods ... to serve as shafts."

avoid dropping horse manure on those carefully raked gravel lanes in castle gardens. Again the experts said: "In England such machines occur very often, with which one can drive oneself around a garden or a park. Reportedly, even in the late Carl Theodor's times, such a driving machine has existed in the castle garden of Schwetzingen, which was trodden by a person from behind and moved by this treading forward with a second person sitting in it." Fig. 0402 shows exactly that garden phaeton, built in London in 1765, which was moved to the royal stables of Munich in 1778, when the Palatian Elector Carl Theodor inherited Bavaria. Since Karl von Drais (1785–1851) was never in Munich before 1830, he could not have seen this carriage in person, but could perhaps have seen a drawing of it during his studies, from 1803 to 1805, at the University of Heidelberg. There was a particularly progressive faculty of technologists there, the result of a modern school founded in Kaiserslautern, with its professors teaching in German instead of Latin.

Far from being an active forester, Karl von Drais had been a city dweller in Mannheim since 1810, a civil servant on paid leave of absence from his duties. This feat had been accomplished by his influential father, the highest judge of the Grand Duchy of Baden. Inspired by his studies in physics, agriculture and architecture in Heidelberg, Drais dealt with the binary mathematics of Leibniz and published on this subject, as well as directing his attentions to more practical inventions, such as a mechanical piano recorder on paper. It should be remembered that the German countries of those days had no general patent law at all, and "inventing was not yet invented." Rather, inventions were dealt with anonymously by the powerful guilds of craftsmen.

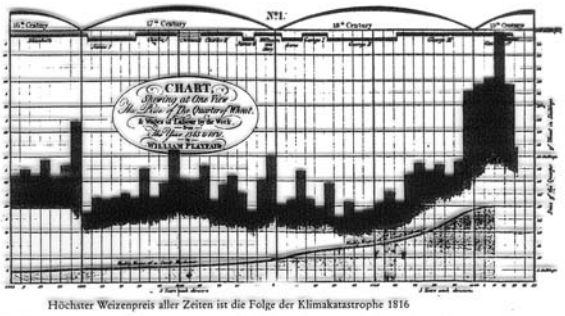
But why did Drais turn his interest to land locomotion in 1812? He left no written records or accounts of this interest, but we know that the first of a series of bad harvests occurred, followed by an extremely cold winter.[4] Moreover, the area had to feed various armies marching through it because of the Napoleonic wars. Famine was the immediate consequence, necessitating the slaughtering of starving horses. The chart by William Playfair of corn prices over three centuries (see Fig. 0403) shows an all-time high in the period from 1810 to 1815 period as a result of these conditions.[5] With the price of oats then playing the same role in transportation as the price of oil today, one can indeed appreciate the need to replace horse-power by human-power. And the cold winter enabled ice skating everywhere, demonstrating that under such ideal conditions, a man on skates could be distinctly faster than on a horse. Drais was an ice skater himself. His starting point was a critique[6] of existing human-powered carriages: "There have been earlier attempts to self-propel a carriage via some machinery. But the machinery was ponderous in surmounting friction, complicated, and therefore never suitable for a really practical use."

Fig. 0404. Drais' Driving Machine No. 2 of 1816 (reconstruction from Ref. 6) "The rear axle has crank-like, exactly dimensioned bends that are trod and thereby turn themselves and the whole axle with the wheels attached to it. The smoothly polished axle runs in brass bushings."



Drais' Driving Machine II 1816 (reconstruction attempt)
The rear axle has crank-like, exactly dimensioned bends that are trod and thereby turn themselves and the whole axle with the wheels fastened to it. The smoothly polished axle runs in brass bushings (Drais 1816)

Fig. 0405. William Playfair's chart showing peak corn prices due to bad harvests, 1812–1816 (from Ref. 5).



1815 = dust eruption of Tambora (Sunda Islands)
1816 = "eighteen hundred and froze to death" in USA
dto. in Europe: snow & rain in summer - crop failure - starvation - slaughtering of horses - breakdown of traffic

Driving Machine No. 1

In October 1813, Drais applied directly to the Grand Duke Carl for a Badenian privilege or monopoly on his four-wheeled prototype called the Fahrmaschine (Driving Machine),[7] after he had demonstrated it for him. He also published it in the *Badisches Magazin* (Badenian Magazine).[8] He claimed a speed of two hours' distance in an hour of time, that is, using his later conversion of one hour in distance to two English miles, a speed of four miles per hour, without using a horse. A report by two experts, an architect and a civil engineer, was commissioned[9] (from which the quotations above are taken), which arrived at the negative conclusion that "humans can achieve a more favorable locomotion with their feet without using this machine." The actual, unstated reason was presumably that no civil servant was allowed to start a side business, the protection of which was the aim of any application for a monopoly. Possibly Drais lacked his father's legal advice on this application, since he wrote from Karlsruhe, not Mannheim.

According to the experts, Driving Machine No. 1 consisted "of a little 4-wheeled cabriolet-type wagon, within which a man can move the axle plus the rear wheels by treading around a wheel with his feet"—the classical treadmill fastened to the back axle. This

probable sequence of evolution (top-down):
Carl Egon von Fürstenberg's fleet of draisines (undated)
The 3- or 4-wheeled machines are not so well suited for travelling on the now common roads... (Drais 1817)

Left: Fig. 0406. Three of Carl Egon II von Fuerstenberg's fleet of undated draisines (approx. 1818, when he married Amalie von Baden). The girl rider wearing trousers is of course an anachronism. "The 3- or 4-wheeled machines are not so well suited for traveling on today's common roads." (Drais, Ref. 19, 1817).

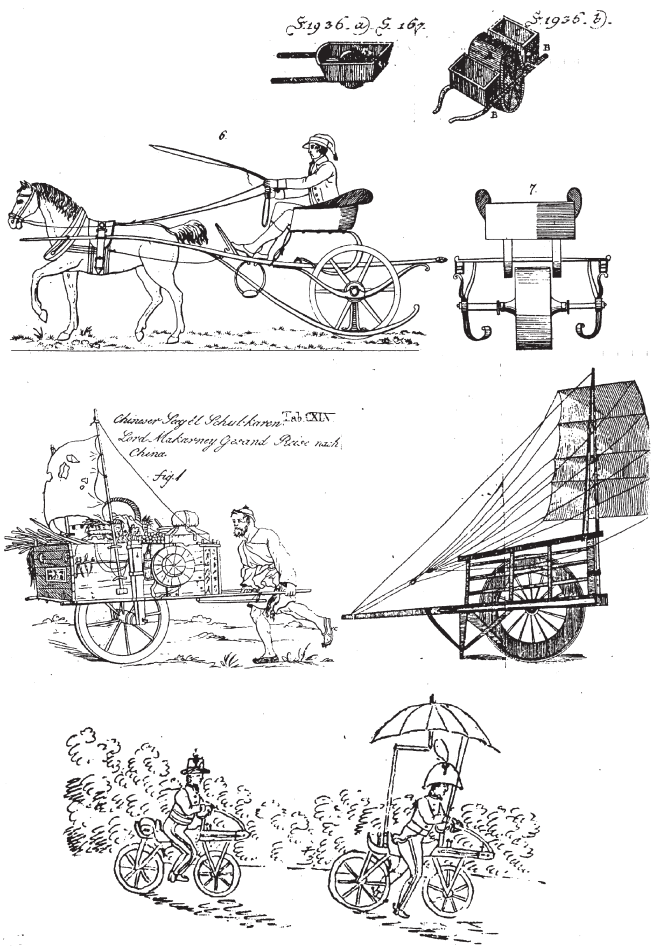
Below: Fig. 0407. Similarities between ice skating and velocipede riding. Top: the ice sled (from Ref. 11): bottom: 3-wheel draisine with correctly positioned passenger. (Photo: Joachim Lessing).

Der Eisschlitten.

Analogies between ice skating and velocipede riding

treadmill presumably consisted of steps, not the bars drawn in the reconstruction attempted in Fig. 0404. Another remarkable feature was that "arriving at steep hills or a very bad road, one takes a horse as an extra team — just as wagoners do — by letting down the direction rods (…) to become shafts."[10] Unfortunately, the wheel diameter is not known. But at least we can now understand why Drais arrived at pushing with his feet on the ground later on. To make treading easier one is tempted to make the treadmill nearly as large as the wheel diameter — but then the treading feet travel the same distance as on the road — so why not let them do exactly that from the outset? Drais also presented the carriage to Czar Alexander I.

Fig. 0408. From wheelbarrow to draisine?
A: Chinese design wheelbarrow (From Ref. 25, 1765);
B: One-wheeled cabriolet Hoppa, 1771 (even the draughtsman was irritated (from Ref. 3);
C: Chinese wheelbarrow with sail according to Macartney (left) and Houckgeest (right) (From Ref. 3 and Ref. 29, respectively)
D: Sketch attributed to Karl von Waldersdorff (Archive Herr v. Waldersdorff, Molsberg, Germany).



of Russia, who was then in Karlsruhe, and proposed presenting it to the Electors at the Congress of Vienna.[11] In the summer of 1814, Drais was actually allowed to travel there, presumably by boat on the Danube, and back with a horse as an extra team (1,000 miles).

Driving Machine No. 2

With his application for a monopoly, Drais had also requested financial support for building an improved prototype, which was also rejected. Yet, without hesitation, he completed it anyway in 1816 and published it.[12] We can read that "the rear axle has crank-like, exactly dimensioned bends that are trodden and thereby turn themselves and the whole axle with the wheels fastened to it. The smoothly polished axle runs in brass bushings." The second passenger trod these cranks with his feet while facing to the front — an improvement. Since we have here cranks similar to the bicycle, we know from hindsight that for today's convenient gear of 84 inches (or 6 meters of development, as one says on the continent), the wheel diameter should have been 7 feet, or 2.1 meters. Unfortunately the wheel diameter of Driving Machine No. 2 is not known. In a letter to the Grand Duchess for support, Drais reminded her later of "ma grande voiture," that is, "my big wagon," but this does not tell us much about the wheel diameter. His article of 1816, which he had made a reprint of, used nearly the same wording as that of 1814[13] and specified nine uses. But he omitted the sentence that after having established a monopoly, "he will present for public evaluation his strict mathematical proof as to why the wagon will work well and durably." It is not known whether these Driving Machines were reported in English newspapers, as was his two-wheeler later. One source wrote later in 1819: "Under the direction of Baron von Drais, a carriage was some years ago constructed to go without horses; but as it required two servants to work it, and was a very complicated piece of workmanship, besides being heavy and expensive, the Baron, after having brought it to some degree of perfection, relinquished the design altogether in favour of the present machine."[14]

1816 — The Year Without a Summer

The climax of crop failures in the year 1816, and snowfall during the summer, was a climatic

catastrophe caused by the volcanic eruption of Tambora on the Sunda Islands, near Bali, in 1815,[15] where 50,000 inhabitants had been killed. The dust created moved to the northern hemisphere, causing permanent bad weather. Even the New England states of America were hit, and people froze to death. The United Kingdom hastily bought corn from the United States, and the German countries from Russia. In 1817,[16] a newspaper in Mannheim, which had a Rhine harbour, wrote that "by the present universal corn shortage, the usual and natural transport links are totally disrupted and a regular circulation of corn supplies to the interior of the country is not possible because so many horses have been slaughtered because of the scarcity of fodder." Yet the bar in Playfair's diagram for 1816–20 is already lower since the good harvests of 1817, 1818, 1819, and 1820 counterbalanced the peak corn price for 1816. This exceptional situation fueled Drais' experiments once more, with the two-wheeler as the result. Yet the return of the horse economy after the first good harvest of summer 1817 also caused the decline of the human-powered velocipede, as a result of bans and fines by the authorities.

The Two-Wheeler Principle

The earliest report of Drais' two-wheeler appeared in the *Badwochenblatt* (Spa Weekly) a paper from what is called today Baden-Baden, more precisely on the occasion of a second spin from Gernsbach over the hill to Baden-Baden.[17] The first reported spin from Mannheim to the relay station towards Schwetzingen took place on 12 June, 1817 — a Thursday. This was one of the best roads in the Grand Duchy of Baden, not a forest track as sometimes suggested, and therefore Drais could average 8 mph on a machine which weighed less than 50 pounds, comparable in weight to a Dutch city bicycle of today. To his contemporaries, it appeared similar to skating on the road: "The principle of the invention is taken from the art of skating."[18]

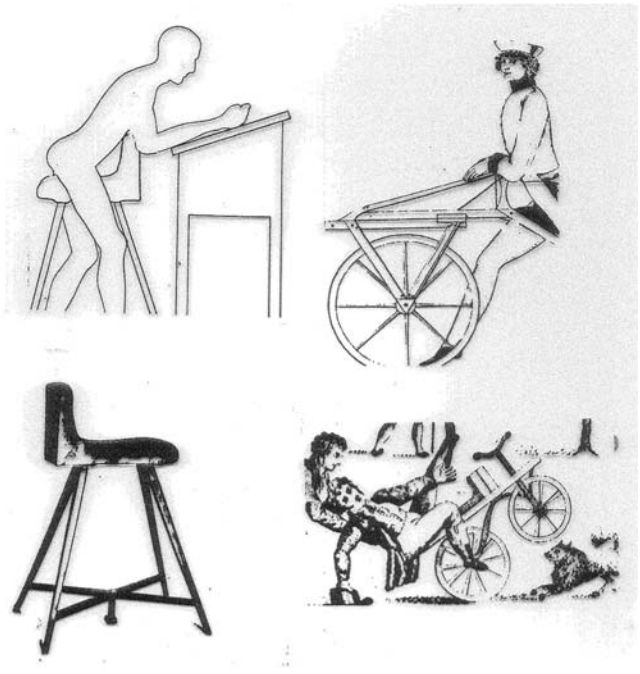
In October 1817, Karl von Drais published a three-page description containing a plate showing the Laufmaschine (Running Machine),[19] as he now called it, plus a male rider. In addition, he described 3- or 4-wheeled running machines with a seat in front to transport the other gender. One each of these machines is still in the Fuerstenberg Collection at Donaueschingen. From the fact that these were not developed later on, but were at hand in 1817, one may speculate that these had been steps in the evolution towards the two-wheeler.

It is tempting to assume that Drais reduced the number of wheels systematically: if three wheels are easier than four, then two wheels must be easier than three. Yet the only evidence that we find in his description ("The 3- or 4-wheeled machines are not so well suited for travelling on the now common roads") does not really support this sequence. All we can say is that he must have found this empirically, since there is no theoretical formula to give this result to this day (see Fig. 0406).

Steering was still done by those vertical steering struts known from the Driving Machines, but these can no longer be let down to serve as shafts for a horse.

Fig. 0407 shows yet another analogy between ice-skating and velocipede riding: the ladies were moved around in chairs, either on ice or on the road, at least in Germany and France. Fewer gender barriers to women skating existed in the Netherlands and England, where a lady's velocipede is extant.[20]

Fig. 0409. Position and balance. Top left: Sitting position at high desk.
Bottom left: Goethe's trestle in Weimar (photo courtesy Stiftung Weimarrer Klassik).
Bottom right: running machine of Anton Burg & Son with chest rest (from Ref. 31).



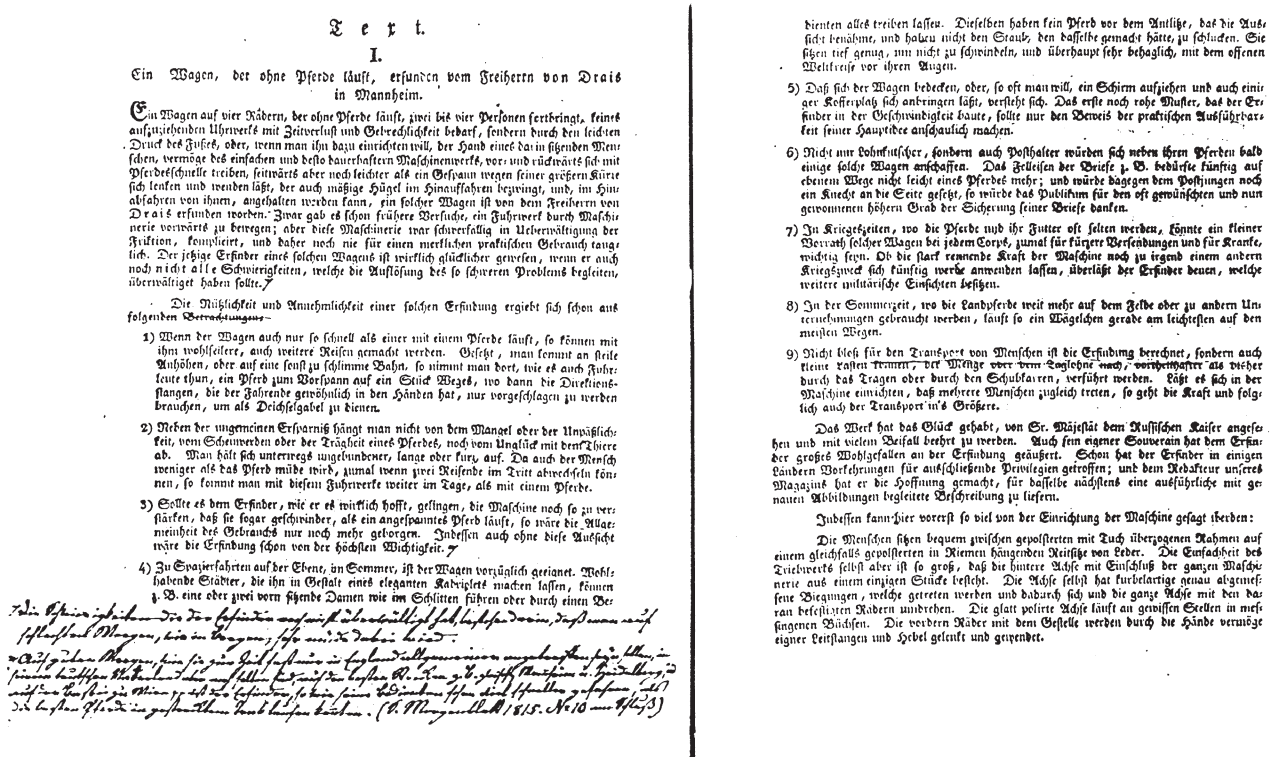
Single-Track Balancing

So where, then, did Drais get the idea of a single-track vehicle? Certainly ice-skating was the activity in which the experience of sliding on one skate and balancing it was of paramount importance. Yet there were also other influences.

In his publication on Driving Machine No. 2,[21] Drais wrote: "The invention is intended not only for the transport of humans, but also small loads can…..be moved more advantageously than by carrying or with a wheelbarrow." And a report on the rich collection of artifacts and models that technologists teaching at the University of Heidelberg were using for demonstrations[22] lists among other vehicles "a wheelbarrow according to Borlach's invention." Although this design by Johann Gottfried Borlach (1690–1763), a saline inspector in Halle, has not yet been tracked down, the mere fact that this wheelbarrow was in the collection of the Heidelberg technologists is an indication that its theory was taught there.

From the work of Needham on the history of Chinese technology,[23] it is well known that the wheelbarrow was a military invention of Chuko Liang in the 3rd century. Called "mu niu," Wooden Oxen, these wheelbarrows, with a large central wheel, were meant to carry a soldier's load: "In the time taken by a man to go 6 ft., the Wooden Ox would go 20 ft. It could carry the food supply (of one man) for a whole year." This wheelbarrow has been the common means of transportation for passengers and goods in China up until recent times. In Europe it did not appear before the 12th or 13th centuries. Builders of castles and cathedrals could cut in half the number of labourers required to haul small loads by substituting a wheel for the front man of the hod or stretcher. But using this technique, half of the load was still carried by the man who pushed, whereas the Chinese design had the wheel below the center of gravity, so no burden was on the man who pushed it. Yet somehow the better Chinese design crept into British agriculture or was reinvented there. Fig. 0408a shows a wheelbarrow with a central wheel or roller, taken from a German technological encyclopedia[24] of the time,

Fig. 0410. Drais' hard-to-find 1816 paper reproduced from his own reprint (courtesy Institut für Stadtgeschichte, Frankfurt). Drais' handwritten footnote says (in the author's translation). The difficulties the invention has not yet overcome are that one gets very tired on bad roads and on hills. "On good roads that are provided generally only in England at present, but are still rare in my German fatherland and on the best circuits, e.g. between Mannheim and Heidelberg, and on the Burgsteige in Vienna, the inventor as well as his servants have driven much faster than the best horses can run in full trot (See **Morgenblatt**, 1815, back page.)."



Text.

I.

Ein Wagen, der ohne Pferde läuft, erfunden vom Freiherrn von Drais in Mannheim.

Ein Wagen auf vier Rädern, der ohne Pferde läuft, zwei bis vier Personen fortbringt, keines aufzuziehenden Uhrwerks mit Zeitverlust und Gebrechlichkeit bedarf, sondern durch den leichten Druck des Fußes, oder, wenn man ihn dazu einrichten will, der Hand eines darin sitzenden Menschen, vermöge des einfachen und desto dauerhaftern Maschinenwerks, vor- und rückwärts sich mit Pferdesschnelle treiben, seitwärts aber noch leichter als ein Gespann wegen seiner größern Kürze sich lenken und wenden läßt, der auch mäßige Hügel im Hinauffahren bezwingt, und, im Hinabfahren von ihnen, angehalten werden kann, ein solcher Wagen ist von dem Freiherrn von Drais erfunden worden. Zwar gab es schon frühere Versuche, ein Fuhrwerk durch Maschinerie vorwärts zu bewegen; aber diese Maschinerie war schwerfällig in Ueberwältigung der Friktion, komplicirt, und daher noch nie für einen merklichen praktischen Gebrauch tauglich. Der jetzige Erfinder eines solchen Wagens ist wirklich glücklicher gewesen, wenn er auch noch nicht alle Schwierigkeiten, welche die Auflösung des so schweren Problems begleiten, überwältiget haben sollte.7

Die Nützlichkeit und Annehmlichkeit einer solchen Erfindung ergiebt sich schon aus folgenden Betrachtungen.

1) Wenn der Wagen auch nur so schnell als einer mit einem Pferde läuft, so können mit ihm wohlfeilere, auch weitere Reisen gemacht werden. Gesetzt, man kommt an steile Anhöhen, oder auf eine sonst zu schlimme Bahn, so nimmt man dort, wie es auch Fuhrleute thun, ein Pferd zum Vorspann auf ein Stück Weges, wo dann die Direktionsstangen, die der Fahrende gewöhnlich in den Händen hat, nur vorgeschlagen zu werden brauchen, um als Deichselgabel zu dienen.

2) Neben der ungemeinen Ersparniß hängt man nicht von dem Mangel oder der Unpäßlichkeit, vom Scheuwerden oder der Trägheit eines Pferdes, noch vom Unglück mit dem Thiere ab. Man hält sich unterwegs ungehinderter, lange oder kurz, auf. Da auch der Mensch weniger als das Pferd müde wird, zumal wenn zwei Reisende im Tritt abwechseln können, so kommt man mit diesem Fuhrwerke weiter im Tage, als mit einem Pferde.

3) Sollte es dem Erfinder, wie er es wirklich hofft, gelingen, die Maschine noch so zu verstärken, daß sie sogar geschwinder, als ein angespanntes Pferd läuft, so wäre die Allgemeinheit des Gebrauchs nur noch mehr gesichert. Indessen auch ohne diese Aussicht wäre die Erfindung schon von der höchsten Wichtigkeit.7

4) Zu Spazierfahrten auf der Ebene, im Sommer, ist der Wagen vorzüglich geeignet. Wohlhabende Städter, die ihn in Gestalt eines eleganten Kabriolets machen lassen, können z. B. eine oder zwei vorn sitzende Damen wie im Schlitten führen oder durch einen Bedienten alles treiben lassen. Dieselben haben kein Pferd vor dem Antlitze, das die Aussicht benähme, und haben nicht den Staub, den dasselbe gemacht hätte, zu schlucken. Sie sitzen tief genug, um nicht zu schwindeln, und überhaupt sehr behaglich, mit dem offenen Weltkreise vor ihren Augen.

5) Daß sich der Wagen bedecken, oder, so oft man will, ein Schirm aufziehen und auch einiger Kofferplatz sich anbringen läßt, versteht sich. Das erste noch rohe Muster, das der Erfinder in der Geschwindigkeit baute, sollte nur den Beweis der praktischen Ausführbarkeit seiner Hauptidee anschaulich machen.

6) Nicht nur Lohnkutscher, sondern auch Posthalter würden sich neben ihren Pferden bald einige solche Wagen anschaffen. Das Felleisen der Briefe z. B. bedürfte künftig auf ebenem Wege nicht leicht eines Pferdes mehr; und würde dagegen dem Postillons noch ein Knecht an die Seite gesetzt, so würde das Publikum für den oft gewünschten und nun gewonnenen höhern Grad der Sicherung seiner Briefe danken.

7) In Kriegeszeiten, wo die Pferde und ihr Futter oft selten werden, könnte ein kleiner Vorrath solcher Wagen bei jedem Corps, zumal für kürzere Versendungen und für Kranke, wichtig seyn. Ob die stark rennende Kraft der Maschine noch zu irgend einem andern Kriegszweck sich künftig werde anwenden lassen, überläßt der Erfinder denen, welche weitere militärische Einsichten besitzen.

8) In der Sommerzeit, wo die Landpferde weit mehr auf dem Felde oder zu andern Unternehmungen gebraucht werden, kauft so ein Wägelchen gerade am leichtesten auf den meisten Wegen.

9) Nicht blos für den Transport von Menschen ist die Erfindung berechnet, sondern auch kleine Lasten [illegible], der Menge oder dem Zoglohne nach, vortheilhafter als bisher durch das Tragen oder durch den Schubkarren, verführt werden. Läßt es sich in der Maschine einrichten, daß mehrere Menschen zugleich treten, so geht die Kraft und folglich auch der Transport in's Größere.

Das Werk hat das Glück gehabt, von Sr. Majestät dem Russischen Kaiser angesehen und mit vielem Beifall beehrt zu werden. Auch sein eigener Souverain hat dem Erfinder großes Wohlgefallen an der Erfindung geäußert. Schon hat der Erfinder in einigen Ländern Vorkehrungen für ausschließende Privilegien getroffen; und dem Redakteur unseres Magazins hat er die Hoffnung gemacht, für dasselbe nächstens eine ausführliche mit genauen Abbildungen begleitete Beschreibung zu liefern.

Indessen kann hier vorerst so viel von der Einrichtung der Maschine gesagt werden:

Die Menschen sitzen bequem zwischen gepolsterten mit Tuch überzogenen Rahmen auf einem gleichfalls gepolsterten in Riemen hängenden Reitsitze von Leder. Die Einfachheit des Triebwerks selbst aber ist so groß, daß die hintere Achse mit Einschluß der ganzen Maschinerie aus einem einzigen Stücke besteht. Die Achse selbst hat kurbelartige genau abgemessene Biegungen, welche getreten werden und dadurch sich und die ganze Achse mit den daran befestigten Rädern umdrehen. Die glatt polirte Achse läuft an gewissen Stellen in messingenen Büchsen. Die vordern Räder mit dem Gestelle werden durch die Hände vermöge eigner Leitstangen und Hebel gelenkt und getrieben.

which had first appeared in the British journal *Museum Rusticum et Commerciale*, in London in 1765.[25]

A one-wheeled cabriolet called "Hoppa" had a short season in Paris in 1771, the inventor being unknown.[26] As is shown in Fig. 0408b, the single wheel was as wide as a roller to provide stability, yet it also needed some side skids as stabilizers. Ginzroth also writes that the girth on the horse had to be tightened too much in order to avoid tilting. As a consequence, the horse either panicked or was unable to corner with the "Hoppa," resulting in many accidents. A "Hoppa" model is not listed in the Heidelberg collection.

There had been expeditions to the Chinese emperor in 1792–93 by the British Lord George Macartney,[27] and by the Dutch Andreas E. van Braam Houckgeest in 1794–95.[28] On their return, both published drawings of a wheelbarrow with a sail, see Fig. 0408c of the former, reproduced from Ref. 3. The same magazine in which Drais would publish his Driving Machine No. 2 eight years later published an article on the wheelbarrow with a sail reported by Houckgeest[29] (see Fig. 0408d). Drais surely must have seen this. One more hint is that in his description, Drais offered to procure orders for a running machine by the local cartwright, with a parasol or a sail as an option. A recently discovered sketch (perhaps wrongly dated 1816 — in hindsight?)[30] shows what may be a combination of parasol and sail, in that the parasol could be tilted forward via a rectangular joint (see Fig. 0408e).

Cramming on the High Desk

As a final remark, the ergonomics of the running machine with a balancing board supporting the underarms may be derived from the typical position of the cramming student, bent over his high desk (see Fig. 0409). As a complement, those times had the so-called high chair or trestle with an upholstered chest rest (the item shown belonged to the classic poet Wolfgang von Goethe in Weimar). In fact, the Austrian running machines of Anton Burg & Sohn relied entirely on the chest rest and omitted the balancing board.[31] Ironically, to support the underarms, Dan C. Lennon still obtained U.S. Patent 4,750,754 some 170 years later, for the so-called "triathlon handlebar."

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Endnotes

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3. Johann Christian Ginzroth. *Die Wagen und Fahrwerke der verschiedenen Völker des Mittelalters und der Kutschen-Bau neuester Zeiten. Munich, 1830* (Reprint Ols Press, Hildesheim/New York, 1979) vol. 4, p. 215.
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7. GLA 236/6735, transcribed in: Michael Rauck. Karl Freiherr Drais von Sauerbronn (*Beiträge zur Wirtschafts- und Sozialgeschichte*, vol. 24). Wiesbaden, 1983, p. 291.
8. *Badisches Magazin* (Mannheim) 5.1.1814 (issue burnt in WWII) Excerpts in: Adolf Kistner. "Zur Geschichte der Fahrmaschine und Laufmaschine des Freiherrn Karl von Drais," Mannheimer Geschichtsblätter, 1933, pp. 169–181.
9. See Ref. 2.
10. See Ref. 8.
11. Kobayashi, Keizo. *Histoire du Vélocipède de Drais à Michaux 1817–1870, Mythes et Réalités*. Bicycle Culture Center, Tokyo, 1993.
12. See Ref. 6.
13. See Ref. 8.
14. *Fairburn's Whimsical Description of the New Pedestrian Carriage etc*. London, n.d. (circa 1819), p. 9, quoted in: Roger Street: The Pedestrian Hobby Horse: At the Dawn of Cycling. Christchurch, 1998.
15. Henry and Elizabeth Stommel. *Volcano Weather — The Story of 1816, the Year Without a Summer*. Newport 1983; ditto *Scientific American*, Dec. 1982. One is tempted to infer that the earlier bad harvests had been a

delayed reaction to the earlier dust eruption of Karang (Bali) in 1808.

16. *Mannheimer Intelligenzblatt*, No. 50, 25.6, 1817.
17. See also Hans-Erhard Lessing. "Karl von Drais' Two-Wheeler — What We Know." *Proceedings of the First International Conference of Cycling History*. Glasgow, 1990. pp. 4–18; The Boneshaker, 12 (1985), No. 9, p. 21.
18. The original news appeared in translation 17 months later in England in *The Courier*, 1818, pp. 11–12.
19. *Die Laufmaschine des Freiherrn Karl von Drais Mannheim 1817* (facsimile edition by Landesmuseum für Technik und Arbeit, Mannheim, 1993). A partial English translation is given by Fairburn, Ref. 14.
20. See Ref. 14.
21. See Ref. 6.
22. Georg Adolph. *Geschichte der öffentlichen Sammlungen der Churpfälzischen Staatswirthschafts Hohen Schule in Heidelberg*. Mannheim, 1789, p. 39.
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24. Johann Georg Krünitz. *Ökonomisch-technologische Encyclopädie*. Berlin, 1782–1843, entry: "Karren."
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26. See Ref. 3, vol. 4, p. 234.
27. George Macartney. *Reise nach China. Nach dem Englischen frei bearbeitet für die deutsche Jugend*. Berlin, 1805.
28. Andreas E. van Houckgeest. *Reise der Holländisch-Ostindischen Gesandtschaft an den Kaiser von China*. Leipzig, 1798.
29. *Magazin der neuesten Erfindungen etc*. (Leipzig), vol. 3 (1808).
30. Courtesy Herr von Walderdorff, Molsberg (who still owns a running machine).
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