

## **The Correspondence of Émile Clapeyron to Gabriel Lamé (1833-1835)**

### **A Tool for Analyzing a Social Network**

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Before to engage their correspondence in 1833, Émile Clapeyron and Gabriel Lamé had a long common past. The first one was born on February 1799 in Paris and was a student of the École Polytechnique from 1816 to 1818, the second one was born on July 1795 in Tours and was a student of the same school from 1814 to 1817. The same year 1818, they entered in the engineer's school École des Mines. From this moment, their lives were near one of the other. Indeed, in 1820, they went together and stayed eleven years in Russia. In Saint Petersburg, they were employed to teach applied mathematics and to build various engineering projects. They lived in two flats at the same floor. Between 1823 and 1831, they published eleven papers together on engineering, mathematics and mathematical physics. It is important to note that, whatever the subject, the authors of the paper were always named Lamé then Clapeyron (Barbin 2009).

When they came back in France, they frequented the saint-simonians (Barbin 2009) and they wrote books together, on railways and civil engineers' works (1832), on professional schools (1833). But the professional life separated the two friends: Lamé became professor of the École Polytechnique in 1832, while Clapeyron became professor of the École des Mines of Saint-Étienne in 1833. Saint-Étienne was a town in the centre of France, surrounded by many mines of coal. When Clapeyron left Paris for Saint-Étienne, Lamé and him promised to write one letter to the other by week. In the beginning, Clapeyron did, but Lamé did not, and the frequency of the correspondence decreased.

#### **Themes, Actors and Nets in the Correspondence**

The correspondence of Clapeyron to Lamé is composed of 38 letters. Until January 2012, it was in the family of Gabriel Lamé, now it is in the École Polytechnique. In the first letter of 1832, Clapeyron wrote about his professional future. The second letter was written in 1833 from England, where he visited mines and railways, 26 letters were written in Saint-Étienne or in Rive-de-Gier (a mine near Saint-Étienne) from 27th January 1833 to 7th July 1834, one letter is written in Zurich where Clapeyron came to give an advice on a bridge, 9 letters were written in Arras (a town in a mining area in the North of France) from 3th December 1834 until 31th May 1835. The correspondence interests many and various subjects because Clapeyron, unhappy in province, always asked news from Paris. This explains why the correspondence permits to learn about people and their business. It is also a valuable tool to understand the life of an engineer of mines in this period.

We defined four principal themes: railways (53 letters mentioned this theme), scientific life (28 letters), professional life (28 letters) and the French society (6 letters). The letters also contain private news. In this paper we will retain only the two first themes.

There are 80 names quoted in the Correspondence, and 33 main actors – that means that they

appear two times or more in the letters. Among them there are 20 polytechnicians (8 are engineers of the *École des Mines* and 6 of the *École des Ponts et Chaussées*), there are also 3 civil engineers, a politician and a banker. The most quoted persons are the banker *Émile Péreire* and the engineer *Stéphane Flach*, who play a part in railways, and the polytechnician *Louis-Antoine Beauhier*, who was the director of the *École des Mines* of *Saint-Étienne* and became a politician in 1830. A complete study of the net constituted by all the names linked to all the themes of the letters shows that there is a strong connexion between them.

Emile Péreire	22	Louis Thénard	5	Antoine-Louis Cercler	2
Louis-Antoine Beauhier	17	Adolphe Thiers	5	Antoine Delsériès	2
Eugène Flach	15	Paul Dubourg	4	Pierre-Louis Dulong	2
Charles Combes	10	Pierre-Dominique Bazaine	3	Jean-Philibert Fénéon	2
Marc Seguin	10	Elie de Beaumont	3	Les Flach	2
Baptiste Legrand	9	Gustave Coriolis	3	Pierre Hachette	2
Camille Picard	8	Armand Dufrénoy	3	Jean-Firmin Malinvaud	2
François Arago	7	François-Noël Mellet	3	Jean Perdonnet	2
Stéphane Flach	5	Jacques Noblet	3	Siméon-Denis Poisson	2
Louis Navier	5	Jean-Victor Poncelet	3	Gaspard de Prony	2
Les Seguin	5	Pierre Arnollet	2	Camille Séguin	2

*Main actors with the number of times they are mentioned*

### **Railways in the Correspondence**

The main subject discussed is the project of the line *Paris Saint-Germain* (27 letters), where *Clapeyron* wrote about the research for financial supports, about the conditions for delivering the project and on his job in the future railway enterprise. The actors about railways in the correspondence are engineers or scientists (13 actors) and politics or bankers (8 actors), and a scientist who was also a politician, *François Arago*.

In his “*Notice sur les travaux*” (*Note on the works*) *Clapeyron* explained the circumstances in which he began to be interested by railways (*Clapeyron* 1858, 5):

*Coming back in France after the Revolution of 1830, my occupations took a more practical nature [...]. In this period, I was surprised by the future of the railways inaugurated by the success of the great experience on these new ways between Manchester and Liverpool, I conceived the idea, and wrote projects on railways from Paris to St Germain; but in waiting that financial circumstances permitted the realization of this thought, I was called in St Etienne as professor of the École des Mines, where I was in charge of a teaching on building.*

Indeed, after his return in France, he was kept on a retainer with half a salary until October 1832. In 1832, the two friends met again polytechnicians in saint-simonian meetings and in the « *Association Polytechnique* », founded by *Auguste Comte* to promote popular education. With *Auguste Perdonnet*, a saint-simonian engineer of the *Ponts et Chaussées*, they wrote a plan on railways (*Perdonnet* 1832). Next year, they wrote a book on *Vues politiques et*

*pratiques sur les travaux publics de France* (Political and practical views on civil works in France) with the brothers Eugène and Stéphane Flachet, two saint-simonian civil engineers, (Lamé 1833a). In 1833, they also wrote a book entitled *Plan d'écoles générale et spéciales pour l'agriculture, l'industrie manufacturière, le commerce et l'administration* (Plan of general and special schools for agriculture, manufacture and administration) (Lamé 1833b). The subjects of these three books are inspired by the philosophy of the saint-simonians.

The philosopher Saint-Simon considered that the engineers occupy an upper place in the society: “engineers are among ‘the producers’, those who give the most important products, those who manage the more useful works for the Nation, they are the real flower of the French Society” (Saint-Simon 1819). One of the most important realization of his disciples will be the railways (Wallon 1908). In 1825, the first paper in favour of railways appeared in the saint-simonian journal *Le producteur*. The saint-simonian Michel Chevalier wrote an important paper on railways in the journal *Le globe* in 1831 and his book *Système de la Méditerranée* in 1832. In this period, the saint-simonians distributed a great lot of “popular sheets” in favour of railways in the streets of Paris. In January 1833, the saint-simonian banker Émile Pereire published papers on the necessity of new laws for railways in the journal *Le National*. Laws in favour of railways were voted in June and July: funds were voted for projects and railways were considered as civil engineering.

### **The « Affair of Saint-Germain » in the Correspondence**

The scientist Henri Navier proposed a project of a railway for goods, from Paris to Rouen in 1825, and Stéphane Flachet wrote a report to compare advantages between such a railway and a canal in 1828. But all the projects on this line failed at this period, and new projects on shorter distances emerged. The saint-simonian banker Émile Péreire submitted a project of a line for passengers from Paris to Saint-Germain on 7th September 1832 (around 20 km). Propaganda in favour of this line was done by Émile Péreire in *Le national*, by Stéphane Flachet in the *Journal du Commerce*, and by Michel Chevalier in the *Journal des débats* (Wallon 1908, 51-63).

Most of the letters of Clapeyron mentioned this project, called “our affair of Saint-Germain”, “our affair of railways” or simply “our affair”. In his letter of the 3<sup>th</sup> February 1833, he wrote: “I am very pleased to see that the railway from Paris to Rouen is not very much advanced, that gives to you time to write the little work about the question of railways lines as we agreed”. Some letters mentioned three rival projects around Paris, like the line from Paris to Pontoise.

The preparation of the project Paris-Saint-Germain needed to find funds and guarantees. In five letters we learn that Péreire researched finances, then the saint-simonian banker Adolphe d’Eichtal and then James de Rothschild accepted. Clapeyron was worry against Lamé because his friend was not busy of the affair sufficiently, especially towards “the capitalists”, like on 3<sup>th</sup> February 1833:

*I ask to you to see Péreire sufficiently and to look after the affair of St Germain. I think that it is time now to consult the capitalists about the question to know if he will obtain funds, we must also think to the guarantee, if the affair is now to the Ponts et Chaussées, it is time to act with energy.*

Indeed, the project submitted by Péreire was approved by the prefects in February 1833 and by the General Council of Ponts et Chaussées in March 1833. But Clapeyron was always anxious, he wrote on 20<sup>th</sup> March 1833:

*My advice is that you does not care of our affair of railways sufficiently, for me it is essential that you keeps the strings otherwise than in the strength of things. Being not any*

*well informed, you will be gently eliminated. You can also have the opportunity to make useful acquaintances among the capitalists. Think to that.*

The technical preparations concerned the drawing of the line Paris Saint-Germain (letter of 3<sup>th</sup> March 1833) and the expenses for maintenance (three letters from February and June 1833). For calculating the costs for maintenance, Clapeyron obtained results by spying on the line Lyon Saint-Étienne of the brothers Seguin, we learn in his letter of 22<sup>th</sup> May:

*I would like to give you some inquiries about the expenses of maintenance. I asked to the director of the railway [Paris St Étienne] Marc Seguin [...]. I have no answer and it is probable that Mr will not give them. [...] In anyway these expenses of maintenance must be huge, all was done with an extreme negligence, it is clear that they must pay all that in repairs. The number of workers counted by me to repair the line St Étienne Rive de Giers was yesterday 40, [...] that is 100 F by day, 3000 F by month, the distance is 22000 m [...] there are important expenses caused to the deterioration of the road [...]. These are the precise data:*

<i>maintenance for railway 10000, 63</i>	<i>maintenance of material 18562,65</i>	<i>various expenses 2438,65</i>	<i>special expenses 1832 8407,71</i>	<i>general expenses 17901,55</i>	<i>rental expenses 5687</i>
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In seven letters, from April 1833 to August 1834, Clapeyron mentioned his scientific experiments on resistance of rails and on inclined planes and curves, and in six letters, from February 1834 to December 1834, on steam-driven machines. He hoped to write two papers on these experiences. These works are motivated by his hopes to become the director of the works of the future line Paris Saint-Germain. We know that he was unhappy to be in Saint-Étienne, and that he tried many possibilities to leave it. He wrote on 22<sup>th</sup> May 1835:

*Did this Conference with Arago take place? Say many things from me to Péreire and to Stéphane. How the affairs of interest among us will be settled definitively? Let me know about all that. It is also good that I would know when the Company will be definitively constituted and when it will judge useful to officially make to Mr Legrand the request of my responsibility of the direction of the works.*

Finally, the project was accepted on 9<sup>th</sup> July 1835. The Company of railways Paris Saint-Germain was constituted officially on 4<sup>th</sup> November 1835 with Émile Péreire as director, Clapeyron, Stéphane Flachet and Lamé as engineers (Leclercq 1987, 81). Clapeyron invented new railway engines because Stephenson was unable to furnish engines able to climb the great declivity of the line (École polytechnique 1897, 194-198). Now, we know that this work were prepared in Saint-Étienne.

### **Scientific Life in Correspondence**

The main subtheme about the scientific life is a paper of Clapeyron entitled “Mémoire sur la puissance motrice de la chaleur” (*Paper on the motive power of heat*) (15 letters). Other letters concern scientific subjects (11 letters), on elasticity and on a paper of Lamé about aether, and the scientific community in Paris (2 letters).

In the end of 1832, Clapeyron sent his paper on heat at the French Academy of Sciences, but it was not accepted by François Arago, Siméon-Denis Poisson, Pierre-Louis Dulong. Then he researched a journal to publish it, as we learn in his letter of 24<sup>th</sup> March 1833:

*Did you bring my paper on the theory of gases to the committee of the journal des Mines? The rather bad opinion of Mr Dulong increases my will to address the paper to*

other judges. Independently of the distance of Mr Dulong from purely theoretical research, it is possible that he does not know the principle of the vis viva, not enough to understand how it is at the foundation of my research. This rejection by Dulong is a true misfortune really, and you could realize how decisive it is for me if you could know his objections.

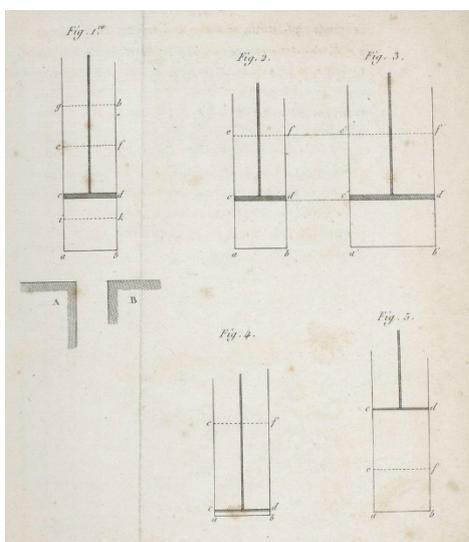
During one year, the publication of the “my paper” made him anxious. He explained to Lamé the reason of the reject on 8<sup>th</sup> April 1833:

*I warn you that Arago does not understand the principle of the vis viva, and so stress on this principle behind him. I am very sorry to get not a better understanding. [...] Let bring my paper to Combes, and to urge him to print it in the Annales of Mines.*

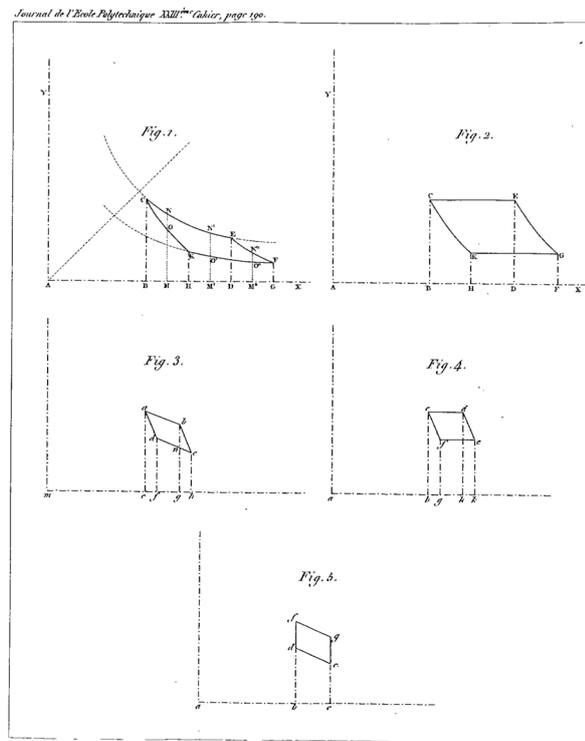
On 10<sup>th</sup> June 1833, the paper was presented by Dufrénoy to the Commission of *Annales des Mines*, but it was not accepted. Finally, it appeared in the *Journal de l'École Polytechnique* (Clapeyron 1834). Clapeyron asked to Lamé to distribute it in his letter of 13<sup>th</sup> August 1834:

*I thank you very much, my dear Lamé, of the care you take with my paper. [...] Please distribute copies to our acquaintances like Poisson, Navier, Poinsot, Libri, Coriolis – in short at almost all the persons to whom you send papers, what do you think? Also you could give copies to Dufrénoy, Brochant, Élie de Beaumont, Combes.*

The scientific references given by Clapeyron in his paper are the Mariotte and Gay-Lussac's laws, confirmed by new experiments of Arago and Dulong, the works of the chemists Bérard and Laroche on the specific heat of different gases (1813), a paper of Dulong on the specific heat of elastic fluids (1828) and the Sadi Carnot's book (Carnot 1824) *Réflexions sur la puissance motrice du feu* (Reflections on the motive power of heat), with a « verification » by Dulong. There is also made a suspicious observation on the hypothesis of Laplace and Poisson (1828). In his letter of 1<sup>st</sup> April 1833, Clapeyron wrote: “I hope that I would be better understood by the engineers than the scholars, who don't attend as we do to the principle of vis viva”.

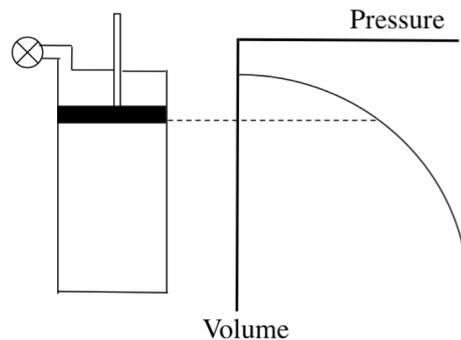


Carnot's figure



Clapeyron's figure

This quotation can be enlighten, if we compare the “Carnot’s cycle” in Carnot (Carnot 1824, 119) and in Clapeyron (Clapeyron 1834, 191). To understand how to pass from one figure to the other, it is possible to use an engineer’s instrument: the Watt’s indicator, which produces a pressure-volume diagram. This diagram was developed by James Watt and by John Southern to improve the efficiency of engines. In 1796, Southern developed a simple technique to generate it by fixing a board, which moves with the piston and traces the “volume” axis, while a pencil, attached to a pressure gauge, moves at right angles to the piston and traces “pressure”. Watt calculated the work done by the steam from the area between the “volume” axis and the traced line. The indicator was unknown by the scientists in this period, but Clapeyron could know it from his stay in Russia or by a paper in the journal *L’industriel* appeared in 1828 (Redondi, 1980, 104).



The pressure volume diagram

## Conclusion

The Correspondence permits to know new things on the preparation of the railway Paris Saint-Germain: on the relations between the different kinds of actors and on the net of the saint-simonians, but also on “the spying” and the experiences of Clapeyron. It permits also to complete the historical information [Birembaut 1976, 191-193] about the Clapeyron’s paper on heat: the relations between the actors in the examination, the refusal and the final acceptance of the paper, and also his reactions about the rejects. At last, we learn about the life of an engineer in the province in the years 1830, about the feeling of isolation and about the more and more difficult relations between the two friends.

## Bibliography

- Barbin, E. (ed) (2009), *Gabriel Lamé. Les pérégrinations d’un ingénieur du XIXe siècle*. Paris: Sabix.
- Birembaut, A. (1976), La découverte des Réflexions ... par Clapeyron, in *Sadi Carnot et l’essor de la thermodynamique*. Paris: Éditions CNRS.
- Carnot, S. (1824), *Réflexions sur la puissance motrice du feu*. Paris: Bachelier.
- Clapeyron, É. (1834), Mémoire sur la puissance motrice de la chaleur, *Journal de l’École royale polytechnique*, tome XIV, 153-191.
- Clapeyron, É. (1858), *Notice sur les travaux*. Paris: Mallet Bachelier.
- École polytechnique (1897), *Livre du Centenaire*, tome I. Paris: Gauthiers-Villars.
- Lamé, G, Clapeyron E, Flachet S, and Flachet E. (1833a), *Vues politiques et pratiques sur les travaux publics de France*. Paris: d’Everat.

Lamé G. and Clapeyron E. (1833b), *Plan d'écoles générale et spéciales pour l'agriculture, l'industrie manufacturière, le commerce et l'administration*. Paris: Bachelier.

Leclercq, Y. (1987), *Le réseau impossible 1820-1852*. Paris: Droz.

Perdonnet, A, Lamé G. and Clapeyron E. (1832), *Notices sur les chemins de fer*. Paris: de Guiraudet.

Redondi, P. (1980), *L'accueil des idées de Sadi Carnot*. Paris: Vrin.

Saint-Simon C.-H. (1819), Première lettre, *L'organisateur*, II, 2, 17-26.

Wallon, M. (1908), *Les saint-simoniens et les chemins de fer*. Paris: Pedone.