Emile Lamm's Self-propelled Tramcars 1870–72 and the Evolution of the Fireless Locomotive

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I Introduction

Emile Lamm (usually referred to as 'Dr' — he was, in fact, a dentist by profession*) of New Orleans, Louisiana, U.S.A., is seldom mentioned in modern books or articles.[1] He did receive some mention in D. Kinnear Clark's classic work of 1878,[2] but even there no study of his ideas was made. Nevertheless, examination of his thinking over a short period of just over two years, from mid-1870 to mid-1872, is extremely interesting and clearly illustrates an important concept, namely, that a theoretically ideal but complex solution of a problem, giving high efficiency, has, in practice, to give way to a much less efficient but much simpler solution. The matter is examined here through Lamm's patent specifications. Lamm himself published very little, and it has not so far proved possible to obtain even the one paper by him to which reference has been found.[3]

The problem Lamm tackled was how to provide self-propulsion in a street-car (i.e. tramcar) without producing smoke. His work led eventually to the development of the type of fireless steam locomotive so extensively used in industrial applications during the past century, namely one relying for its steam on the heat stored in superheated water under high pressure, the heat being injected at the base station by high-pressure steam fed into the water in the insulated container on the locomotive. Fireless steam propulsion had not, it is believed, been tried in the U.S.A. before 1870, and Lamm was probably quite unaware of Colburn's earlier proposals in Britain,[4] which, however, did not lead to practical trials of a true fireless system.

In the two-year period mentioned, Lamm was granted six U.S. Patents. The systems disclosed in these patents are described fully, in the present author's terms and using simplified schematic diagrams, in

*An interesting short biography is reproduced in the Appendix.

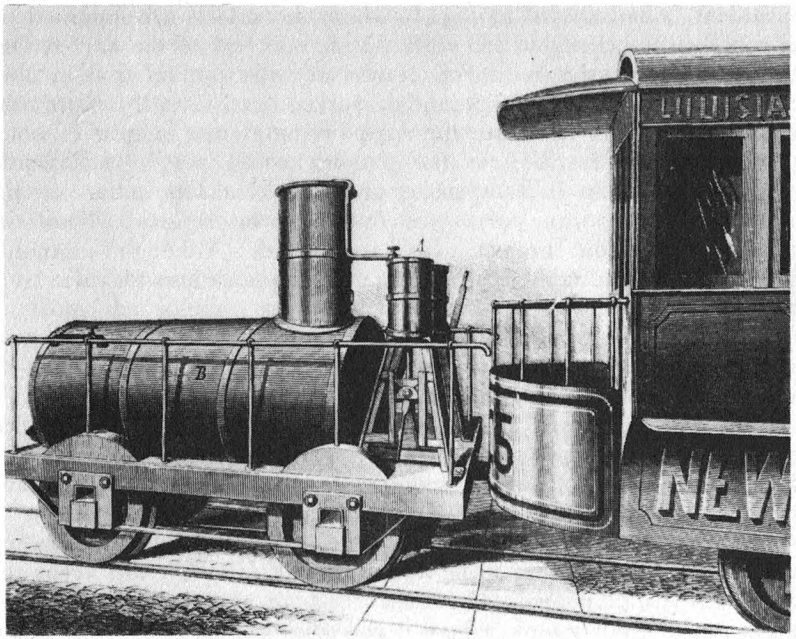

Figure 2. Fireless steam locomotive hauling tramcar, by E. Lamm, 1872 (from *Scientific American*, **27**, 1872).

locomotive was evidently successful, for by 1874 we read that such locomotives (in the plural) 'are in regular use' in New Orleans.[10]

II Lamm's Patents, 1870–72

1 U.S. PATENT No. 105,581 DATED 19 JULY 1870, 'AMMONIACAL GAS ENGINE'

A schematic diagram of the system disclosed by this patent is shown in Fig. 3. Liquefied ammonia gas is pumped into the vessel indicated, through the pipe A, until it is full. This vessel comprises a number of vertical tubes, below the dashed line, so that a large heating surface is provided. It is immersed in the outer tank which is two-thirds full of dilute ammonia solution in water; this tank is filled through pipe B and emptied through pipe C. The top and bottom of the ammonia-gas vessel are connected to the buffer vessel, from which the gas input to the engine is taken. The exhaust from the engine, i.e. low-pressure ammonia gas, is taken by the pipe shown to the bottom of the tank of ammonia solution, where it dissolves. To prevent leakage of ammonia gas from the piston-rod glands and from the valve-gear of the engine,

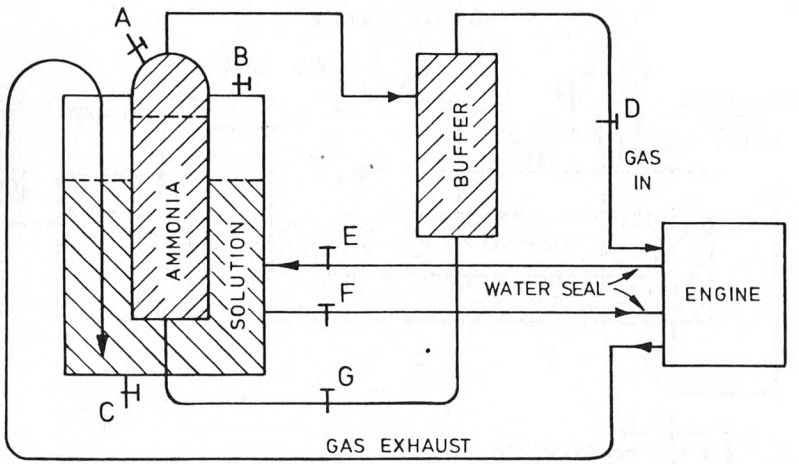

Figure 3. Lamm's ammonia engine of July 1870. (Stopcocks in all diagrams are indicated thus ∓.)

these parts are enclosed in water, which tends to circulate through the outer tank by means of the pipes shown.

The cock D controls the power and speed of the engine. Cocks E and F control or isolate the water seals of the engine. The way cock G is used is not clear.

At the end of the operation, most of the liquefied ammonia has been used and has been transferred into solution in the tank. It is drained out through pipe C and the solution is treated for the recovery of the ammonia as liquefied gas, the tank being refilled with dilute solution. The inner vessel is at the same time recharged with liquefied ammonia gas already prepared. The engine is then ready for the next period of operation.

U.S. Patent No. 121,527 dated 5 December 1871, 'Tender for Gas Boilers', was a small improvement, consisting of the addition of another vessel containing liquefied ammonia gas and connected to the bottom of the main vessel in Fig. 3. The object appeared to be the maintenance of a higher pressure of gas as the operation proceeded.

2 U.S. PATENT No. 124,495, DATED 12 MARCH 1872, 'IMPROVEMENT IN AMMONIACAL GAS ENGINE'

This revised scheme for the ammonia gas engine is shown diagrammatically in Fig. 4. The 'boiler' is now horizontal instead of vertical, and instead of being made of tubes, is an ordinary cylindrical vessel with longitudinal tubes like the water-tubes of an ordinary steam boiler. It is immersed in a horizontal tank of dilute ammonia solution. The buffer vessel of Fig. 3 has been dispensed with. Evidently the

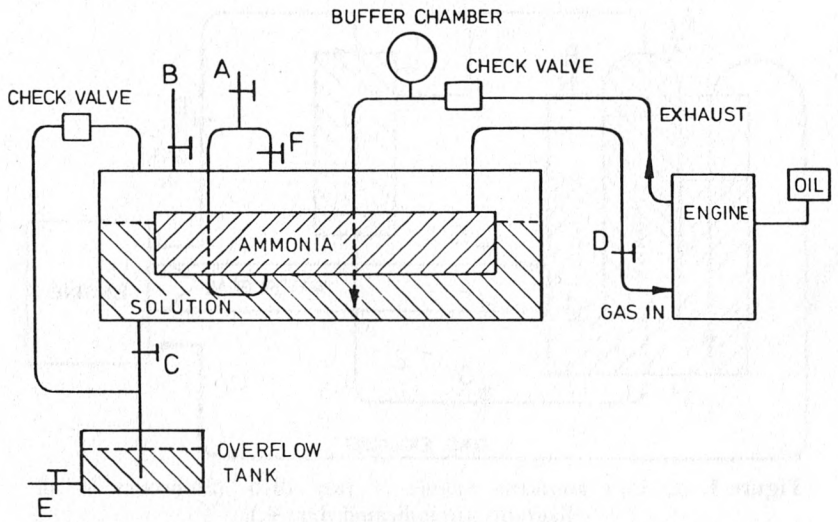

Figure 4. Lamm's improved ammonia engine of March 1872.

water seal of the previous scheme was not found satisfactory, as there is now an oil seal in the engine. The exhaust pipe has a buffer chamber with a check valve in order to relieve back-pressure on the engine valve which otherwise would tend to lift it off its seat at the moment of exhaust. An overflow tank containing ammonia solution is provided, so that if the ammonia gas from the exhaust of the engine does not dissolve quickly enough in the main tank, the excess gas will pass via the check valve to dissolve in the overflow tank. The check valve prevents passage back to the main tank if the pressure in the overflow tank rises too much.

The ammonia tank is filled via cock A, the outer tank via cock B. The ammonia solution is drained, at the end of an operation, by opening cocks C and E, and the process can be accelerated by opening cock F (while A is closed) so that the residual gas pressure in the inner vessel (or boiler) aids the gravity discharge.

3 U.S. PATENT No. 124,594 DATED 12 MARCH 1872, 'IMPROVEMENT IN CHLORIDE-OF-CALCIUM ENGINES'

The equipment on the vehicle was quite simple, as shown in Fig. 5(a). The equipment at the charging station was relatively complex and Lamm evidently felt it necessary to include it in the patent; it is shown schematically in Fig. 5(b).

The inner vessel in Fig. 5(a) supplies steam from the superheated water to the engine; the outer vessel contains a saturated solution of

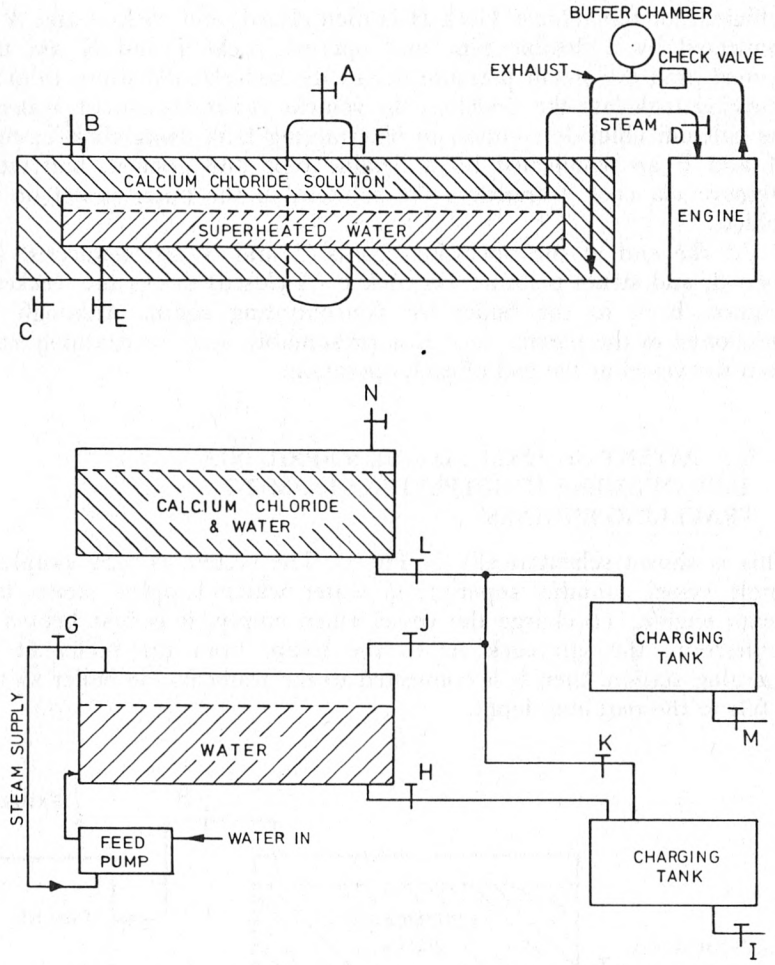

Figure 5. Lamm's 'Chloride of Calcium Engine', March 1872:
(a) Unit on the tramcar
(b) Stationary unit for charging mobile unit.

calcium chloride at its boiling point. The exhaust steam from the engine is fed via a check valve and buffer chamber (as in the ammonia-gas engine patent) to the bottom of the calcium chloride solution, where it condenses.

In Fig. 5(b), both the main vessels, one for making the saturated solution and the other the superheated water, are boilers heated by a fire. The water boiler has a feed pump driven by its own steam through cock G. To charge the vessel on the vehicle with superheated water, cock H is opened and the charging tank fills; the quantity is just

sufficient for the vehicle. Cock H is then closed, and cocks I and A are connected by a flexible pipe and opened; cocks J and K are then opened, and the steam pressure drives the superheated water from the charging tank into the vessel on the vehicle. A similar process transfers the calcium chloride solution to its charging tank using cock L; cocks M and B are connected by a flexible pipe and opened, and steam pressure via cock J transfers the solution to the outer vessel on the vehicle.

At the end of the operation, cocks C and N are connected and opened, and steam pressure via cock F (A closed) drives the weakened solution back to the boiler for concentrating again. Although not mentioned in the patent, cock E is presumably used for draining water from the vessel at the end of each operation.

4 U.S. PATENT No. 125,577, DATED 9 APRIL 1872, 'IMPROVEMENT IN SUPPLYING STEAM TO TRAVELING ENGINES'

This is shown schematically in Fig. 6. The system is very simple. A single vessel contains superheated water which supplies steam to a steam engine. To charge the vessel when empty, it is first heated by connection, through cock A, to the steam from the boiler at the charging station; then it is connected to the water in the boiler so that it fills to the required depth.

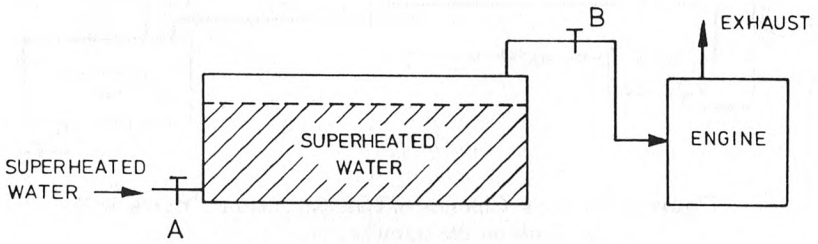

Figure 6. Lamm's fireless steam engine, April 1872.

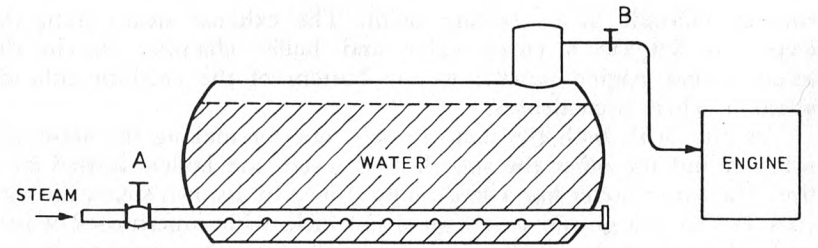

Figure 7. Lamm's improved fireless steam engine, July 1872.

5 U.S. PATENT No. 129,969, DATED 30 JULY 1872, 'IMPROVEMENT IN SUPPLYING STEAM TO TRAVELING ENGINES'

This is shown in Fig. 7. It differs from the scheme of Fig. 6 in one important way: instead of the vessel being recharged with superheated water at the beginning of each operation, the water is not removed from the vessel, but instead is re-superheated by passing steam into it through cock A and the perforated tube in the bottom of the vessel. The total area of the perforations should equal the cross-sectional area of the tube.

This patent was re-issued with expanded description and claims as Re-issue No. 5083, dated 1 October 1872.

III The Development of Fireless Locomotion during the 1870s

Lamm seems to have made the first-ever fireless steam locomotive in 1872, as described in Section I. Other people, however, were quick to copy it. How Lamm's patent protection was used, if at all, is not clear.

Trials of two fireless locomotives took place on the tramway between East New York and Canarsie (3.5 miles) in October 1873[11] and again a month or two later.[12] They were made by the Fireless Engine Co. (president G.L. Laughland, consulting engineer C.H. Haswell). One locomotive did the return trip in just under 30 minutes' running time, hauling a tramcar carrying 120 passengers, with steam pressure falling from 180 to 45 lb/in^2. Its weight was 4 ton 3 cwt; it had condensers and worked without expansion. The second locomotive was tested by R.H. Buel and H.L. Brevoort; it seemed to be less successful, taking 35.5 minutes to cover 4.4 miles, with steam pressure falling from 142 to 22 lb/in^2. This locomotive certainly used the system of Fig. 7, and the reports inferred that both locomotives were constructed to Lamm's design.

In 1875 a fireless steam tramcar was made by Bède and Co. in Belgium for use by the Société Générale de Tramways.[13] The hot-water vessels comprised four horizontal ones, placed under the seats, and two upright ones, totalling 50 cu. ft., all well-lagged. Three cylinders, 4.5 in. by 14.2 in., drove on to one axle. Initial steam pressure was 162 lb/in^2, and the car could run for about 50 minutes. It was apparently kept in use for a year or two, but was found expensive to operate.

Also in 1875, details of a fireless steam tramcar designed by L.J. Todd, of Leith in Scotland, were published.[14] A drawing of the car is shown in Fig. 8, and an exterior view of it, showing the arrangement for charging the hot-water reservoir, is reproduced in Fig. 9. Clark[15] states that the car was constructed, but there is room for doubt on this point, because, while the article in *The Engineer* is so worded as to *infer*

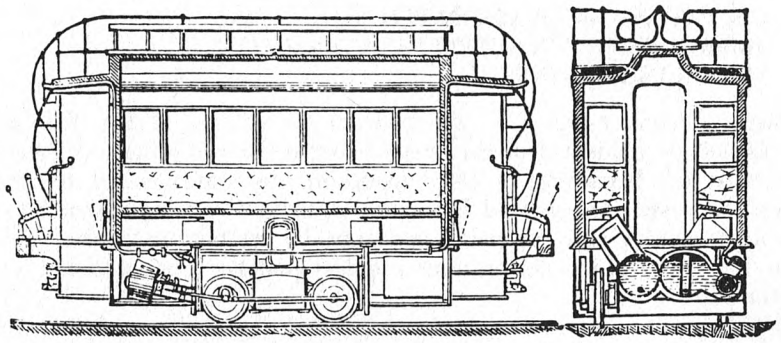

Figure 8. Todd's fireless steam tramcar, 1875 (from D.K. Clark, *Tramways*).

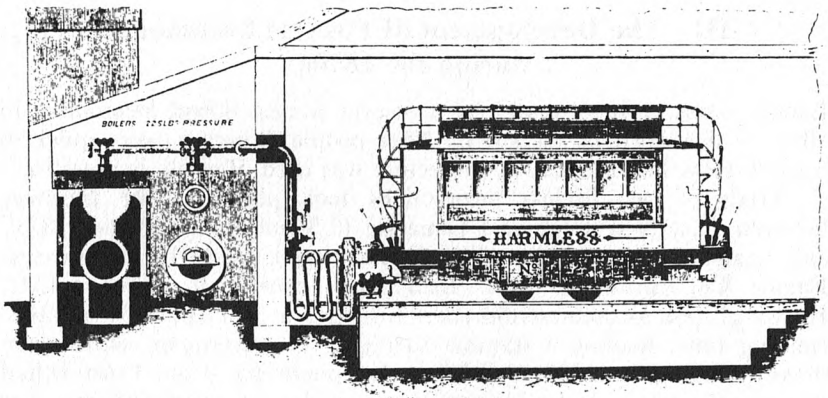

Figure 9. Todd's fireless steam tramcar, 1875, showing charging arrangements (from *The Engineer*, **39**, 1875).

that the car was actually in existence, it carefully avoids definitely saying so; and furthermore, no reports of its trials have been found. Todd was, however, an experienced designer of tramway vehicles and locomotives which had actually been constructed, and he had approached the idea of the fireless steam engine quite logically, but by a process of thinking very different from Lamm's. He set out his ideas very fully in 1874,[16] and made it clear that he had already tried out a tramway locomotive which was designed to run mainly on stored heat in an extra-large boiler, the very deep fire being used to generate this heat mainly while the machine was waiting at the terminus, and closed up during the journey, so that no smoke would be produced. The progression from this idea to the fireless steam machine was natural, although he generously credited it to Lamm.

Todd made a patent application in 1875 which clearly describes the

basis of the fireless tramcar:[17]

> Relates to tramcars, omnibuses, etc., which are propelled by steam generated in stationary boilers and stored in receivers on the carriages. In one arrangement, two receivers, placed longitudinally beneath the floor, have at one end a cylinder and piston arranged to drive two coupled pairs of wheels, and at the other end an extension to balance the weight of the cylinder, domes or steam spaces being fitted to the receivers so as to project up laterally under the seats. The cylinders have jackets supplied with water or steam from the receivers.

It seemed a sound and practical design.

Of all the work done on fireless locomotion during the 1870s, the best documented is that by Léon Francq of Paris. His system was essentially that patented by Lamm in 1872 (Fig. 7). It is curious that

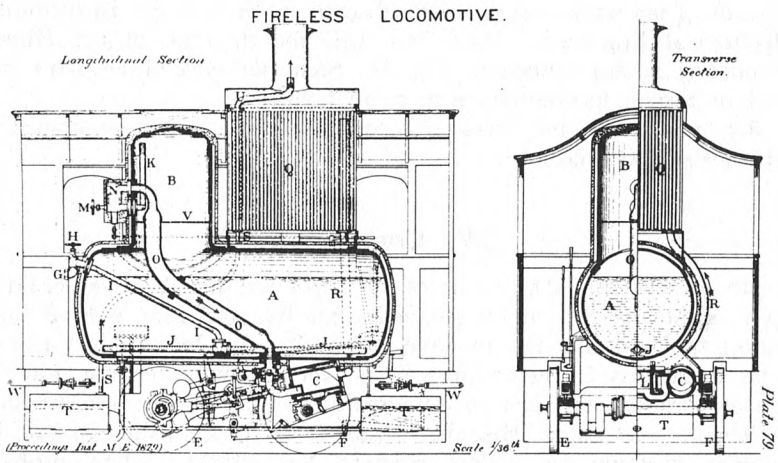

Figure 10. Francq's fireless tram locomotive built by Hunslet Engine Co. in 1879 (from *Proc. Inst. Mech. Eng.*, 1879).

A hot-water reservoir, holding 400 gallons, 220 lb/in^2 pressure
B dome
C cylinders
G nozzle for introducing high-pressure steam
J perforated pipe for steam entry to water
K steam outlet
M valve
N expander, to deliver steam to cylinders at constant pressure
O steam-pipe to cylinders, passing through reservoir to provide heat to dry the steam
Q air-cooled condenser
S pipe to feed condensate to tanks T
U exhaust tube for any steam not condensed.

in an account of Francq's work in 1879,[18] it is stated that Francq 'introduced the improved plan of reheating the water in the reservoir by the injection of steam at high pressure', whereas in Lamm's scheme 'the reservoir applied by him to his locomotive was recharged with water (heated under pressure) at suitable intervals'. Why this myth arose is not clear, since Lamm's locomotive of 1872, according to Clark's description already cited in Section I, quite clearly had its water heated by steam-injection. Nevertheless, Francq obtained patents.[19] His earliest fireless locomotive, of 6.5 tons empty, was tried on the tramway between Saint-Augustin and the Boulevard Bineau,[20] and did the round trip of 5 miles with pressure falling from 156 to 50 lb/in^2. The exhaust steam proved an annoyance. Later locomotives had condensers as well as the higher pressure of 213 lb/in^2; these performed well on the tramway between Rueil and Marly-le-Roi (near Paris), where over 10,000 km were run each month. A rather similar tramway locomotive was built for Francq by the Hunslet Engine Co. of Leeds in 1879, but it is not known if it was ever put to work.[21] A full account of his work was given by Francq in 1879 to the Institution of Mechanical Engineers,[22] and from this the drawing of the Hunslet locomotive is reproduced as Fig. 10. Some account of Francq's later work on fireless locomotives is given by Clark.[23]

By this time the fireless locomotive had been developed to substantially its final form.

IV Conclusion

It can be seen that the decade of the 1870s was the decisive period for the evolution of the fireless steam locomotive, and that, even if Emile Lamm was not the first to have the basic idea, he certainly showed great originality in his approach via the ammonia engine and was almost certainly the first to demonstrate a true fireless self-propelled vehicle or locomotive. His abandonment of theoretically efficient but complex systems for a less efficient but simple system probably illustrates a principle of general validity. It is perhaps a matter of some surprise that a dentist of that period, with, as far as is known, no scientific or engineering training, should not only be able to invent and design effective and complex machines but should also be able to apply to the process of invention an understanding of quite subtle scientific matters.

V Acknowledgements

I am very grateful to Mr J.A. Crabtree and Mr J.G.B. Hills for discussion and comment on this work and for valuable information and references; and also to several libraries, notably those of the Science Museum and of the Institution of Civil Engineers.

Appendix

BRIEF BIOGRAPHY OF EMILE LAMM FROM *APPLETON'S CYCLOPAEDIA OF AMERICAN BIOGRAPHY* (NEW YORK, 1887)

LAMM, Emile, inventor, b. in Ay, France, 24 Nov., 1834; d. near Mandeville, La., 12 July, 1873. He was educated at the Collège royal in Metz, but came to the United States in 1848, and became a dentist, following his profession in Alexandria, La., until the civil war. Dr. Lamm served in the Confederate army under Gen. Braxton Bragg during the war, and after its close resumed his practice in New Orleans. As a boy he showed decided mechanical ingenuity, and in 1869 devised an ammoniacal fireless engine for the propulsion of street-cars. The system was tested by street railway companies in New Orleans, New York, St. Louis, and other cities, with satisfactory results; but owing to Mr. Lamm's premature death and unfortunate management on the part of the company that controlled the patent, the motor has not been put into practical operation in the United States. The system has been introduced in France and Germany, where it has been improved and perfected, so that at present (1887) it is extensively used for street-cars and vehicles. During his work on this invention he became impressed with the facility with which the vapour of water may be condensed, even at an elevated temperature, in water under high pressure; and pursuing his experiments, he produced another fireless engine, which he patented in 1872, and which is now in practical use. He also invented a method for the manufacture of sponge gold, for which he obtained a patent and a gold medal at the Mechanics' fair in New Orleans. This process is used largely by dentists throughout the United States. Dr. Lamm was a fellow of the New Orleans academy of sciences. He was drowned.

NOTE by the present author: The statement above that the ammonia engine had been successful and used extensively in Europe is contrary to D.K. Clark's testimony and is not supported by any references I have found.

Notes

1. An exception is R.J. Buckley, *A History of Tramways* (Newton Abbot, 1975), where Lamm gets several lines. One might expect more in A. Baker and A. Civil, *Fireless Locomotives* (Tarrant Hinton, 1976), but in fact there is less.

2. D. Kinnear Clark, *Tramways, their Construction and Working* (London, Vol.1, 1878; Vol.2, 1882; 2nd edition, 1894).

3. E. Lamm, 'Locomotive without fire', *American Artisan*, 3rd series, 3, c.1871 or 1872, p.312. This reference is given in Bruno Kerl, *Repertorium der Technischen Literatur, 1869–1873* (Leipzig, 1878), p.790. English-language bibliographies of periodicals so far consulted do not list the *American Artisan* before 1880.

4. Z. Colburn, 'On the working of underground railways', *The Engineer*, 18 (1864), 321–3 and 335–6. Colburn was not concerned with tramways, but rather with the Metropolitan Railway in London.

5. A. Armour (communicated by E. Lamm), British Patent 517, dated 25 Feb. 1871; and W.R. Lake (communicated by E. Lamm), Brit. Pat. 903, dated 25 March 1872. A curious point is that the ideas disclosed in the second British Patent *antedate* the corresponding U.S. Patents Nos. 125,577 and 129,969 discussed in Section II of the paper, in the second case by over four months.

6. Clark, op. cit., 1878 edition, pp.316–17; 1894 edition, pp.413–14; also see 'Ammonia as a motive power for street cars', *The Engineer*, 33 (1872), 23–24. On the question of corrosion of the iron parts by ammonia, Mr J.G.B. Hills informs me that: 'Practical ammonia engines, with iron parts, have been made since Lamm's time. They were formerly used in ice works to recover part of the energy used in the gas compressors. Ammonia vapour, and the liquefied gas, do not corrode ferrous materials (they are often handled in mild steel pipes and vessels in chemical and refrigerating plants). In the presence of water or water vapour, they are severely corrosive. Copper alloys are corroded wet or dry, and have to be avoided.' The trials in New Orleans were described in *Scientific American*, 25 (1871), 290–91; this article mentioned that the Ammonia Propelling Company had been formed to exploit the invention. Reference was also made to a quite different kind of ammonia engine invented in France in 1865 by Ch. Tellier using the vacuum produced in a cylinder filled with ammonia gas when water is injected. The reference given was to *Trans. American Institute*, 1865–6, p.436, but I have been unable to trace this journal for the years quoted. Two brief relevant notes were published in *Comptes Rendus Acad. des Sciences*, Paris, 60 (1865), 59 and 1195.

7. Although at first sight it seems unlikely that steam could give up its latent heat to a liquid hotter than itself, the principle is supported by O. Lyle, *The Efficient Use of Steam* (H.M.S.O., 1947), p.790, and was apparently used in practical locomotives by Honigman at Aachen about 1885.

8. Lyle, cited in the previous reference, discusses methods of blowing steam into a liquid at pp.354–6; unsuitable methods caused much noise, vibration, and disintegration of plant. He says: 'Perforated pipes are often used, sometimes quite successfully. They often fail, however, and sometimes hammer badly. . . . If a perforated pipe is to be used it should be long with small holes well spaced.'

9. 'Fireless locomotive', *Scientific American*, 27 (1872) p.118; Clark, op. cit., 1878 edition, pp.317–18; 1894 edition, pp.414–15.

10. 'The fireless locomotive', *The Engineer*, 37 (20 Feb. 1874), 135.

11. *The Engineer*, 36 (24 Oct. 1873), 276.

12. *The Engineer*, 37 (20 Feb. 1874), 135.

13. Clark, op. cit., 1878 edition, pp.336–7; 1894 edition, pp.430–1. The relevant patents are Belgian Patents Nos. 36129 and 38008 of 1875.

14. 'Todd's self-propelling tramway car', *The Engineer*, 39 (9 April 1875), 240 and 243.

15. Clark, op. cit., 1878 edition, pp.334–5; 1894 edition, pp.412–13.

16. L.J. Todd, 'On working street railways by steam power', *The Engineer*, 38 (24 July 1874), pp.65–71.

17. British Pat. No. 355, dated 30 January 1875. This patent was filed only as a provisional application; the quotation is from the official abridgement.

18. 'Fireless locomotives', *Engineering*, 28 (17 Oct. 1879), 306, plus 2pp. of plates.

19. e.g. French Patent No. 108,954, dated 22 July 1875; Belgian Patent No. 37566 dated 2 August 1875; Brit. Pat. No. 2253, dated 6 June 1878. It is a matter of interest that in published accounts of Francq's work on tramways a decade later, his fireless locomotives were described as being on the 'Système Francq et Lamm'. Thus Lamm's contribution was still being recognized by Francq fifteen years after Lamm's death. See (i) 'Traction au moyen des Locomotives à Vapeur sans Feu', reprint from 'Rapport de la Société Indo-Néerlandaise de Tramways', (Paris, 1888); and (ii) 'Traction et Moteurs à Vapeur sans Feu', booklet published by La Compagnie d'exploitation des Locomotives sans Foyer (Paris, n.d.); both in the Library of the Institution of Civil Engineers.

20. Clark, op. cit., 1878 edition, pp.332–4; 1894 edition, pp.509–10.

21. A. Baker and A. Civil, *Fireless Locomotives* (Tarrant Hinton, 1976), pp.52–3. Plate 34 of this work shows a photograph of the Hunslet locomotive.

22. L. Francq, 'On fireless locomotives for tramways', *Proc. Inst. Mech. Eng.* (1879), 610–26, plus plates 79 and 80. The discussion on pp.626–41 is also interesting.

23. Clark, op. cit., 1894 edition, pp.512–13.