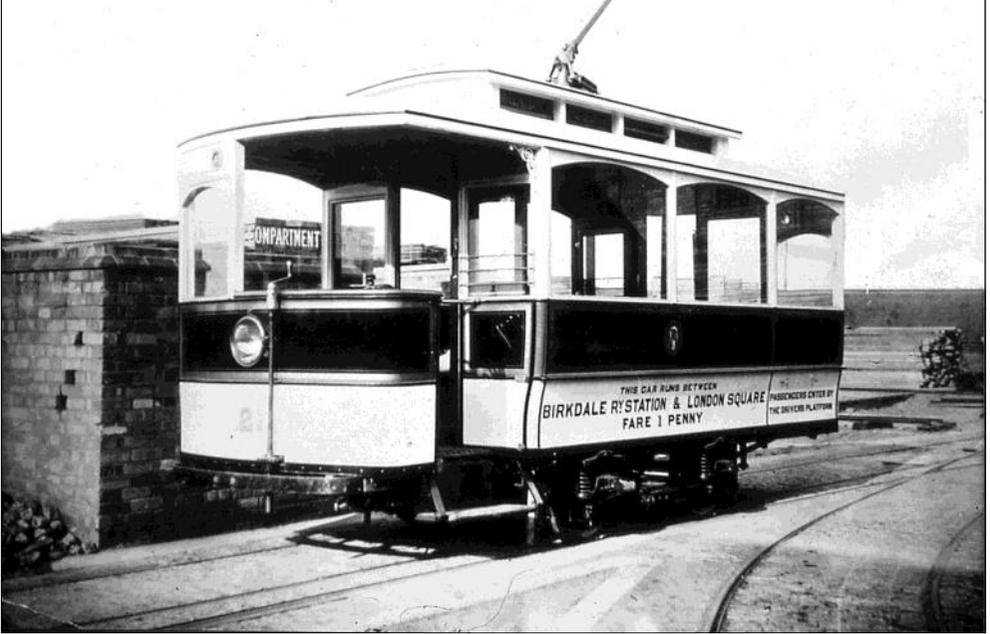


The Raworth Demi-car

John Prentice takes a look at these popular trams with particular reference to the Majestic Trams 00 kit.



Today, with modern electronics, the use of regenerative braking on electric tramways, railways, metros, hybrid buses, hybrid cars and even Formula 1 racing cars is commonplace, but at the start of the 20th century it was almost unheard of. Likewise, small front entrance, one-person operated buses now run everywhere on light traffic routes where a full size bus would be uneconomical. Having said that, the idea of a small and lightweight tram that could be operated by one man and would save electricity by regenerative braking was largely brought about commercially over 110 years ago by one person, John Smith Raworth.

Raworth demi-cars are perhaps one of the most popular trams to model in all scales. I personally know of large scale models in 1/16 by Bob Appleton (Gravesend), Ron Leach (Maidstone), Richard Elliott (Erith) and in 1/24 by Tony Cooke (Plymouth, Halifax, and Chester) and there are many others. In 7mm there is a Gravesend card kit by Alphagraphix and I remember at one time seeing a nice Erith car mod-

Built by Brush, this was the original prototype demi-car which ran in Southport as car 21 from 1903 and was used to evaluate Raworth's systems. It had two side windows in the saloon and a partly open front.

elled in 1/32. However it is the smaller 00 scale on which I will concentrate, as with the re-introduction by Majestic Trams of the former Tramalan white metal kit, the demi-car is once again available to a wide range of modellers. There were only 23 Raworth demi-cars, operating on 16 tramways, but there are far more models around than that!

Background History

John Smith Raworth (1846-1917) was an electrical engineer of some renown. After earlier employment with R & W Hawthorne in Newcastle, Wren & Hopkinson in Manchester and in the 1870s a spell with Siemens, he became Chief Engineer with Anglo-American Brush at their London office. After Brush's takeover of the

Right:

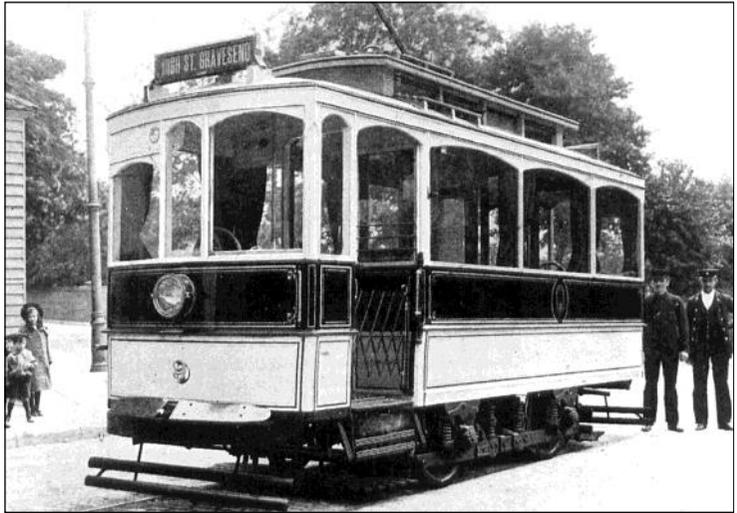
The first production demi-cars were cars 9 and 10 in Gravesend, built early in 1904 also by Brush. This is car 9 on the Windmill Street route in 1904 at the southern *Old Prince of Orange* terminus.

Below:

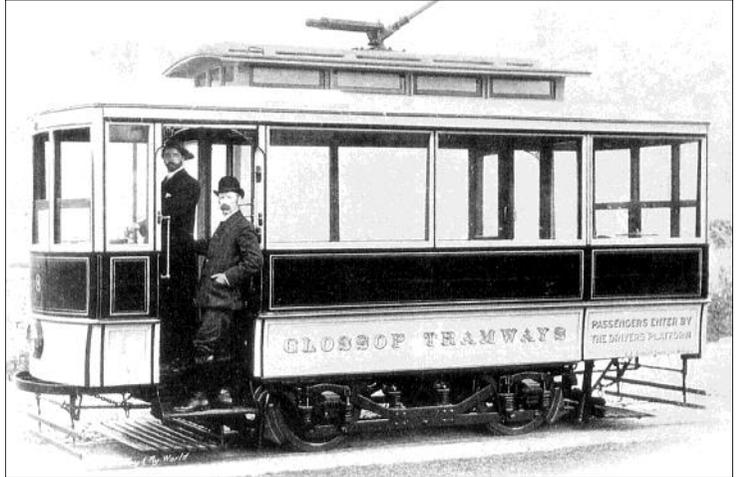
Next is this two-windowed car 8, similar to Gravesend but without the arched window tops, built by the British Electric Car Co. for Glossop in August 1904. Note the unusual BEC truck. One of the "crew" is probably J.S. Raworth's son, Alfred.

Photos:

Tramway & Railway World.



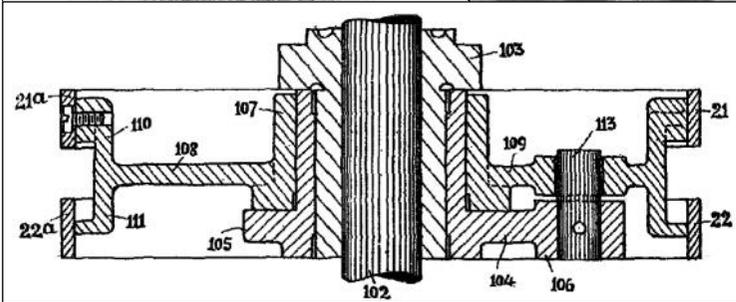
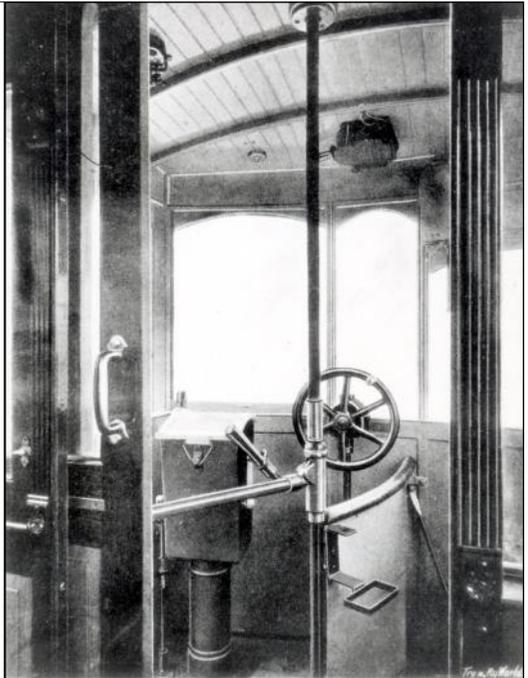
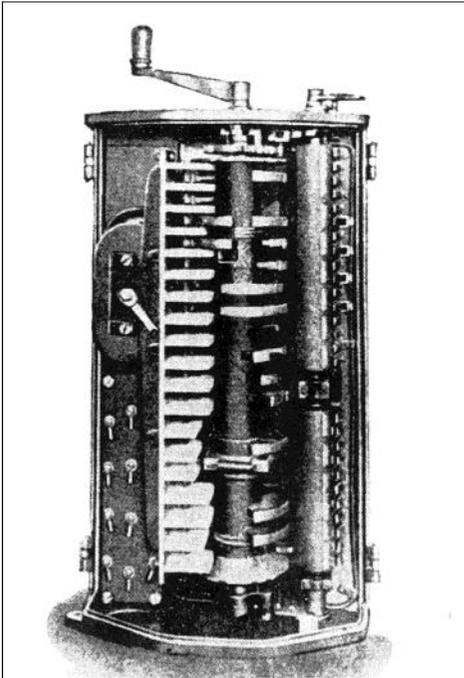
Falcon Works in Loughborough, he became Superintending Engineer there and, from 1891, General Manager. In 1897 he became a part-time consultant on the board of Brush and from 1896 he was Technical Director on the main board of British Electric Traction (BET). He was on the board of the North Staffs Tramway company where Emile Garcke, the BET Managing Director, was chairman. He also became chairman himself of the tramways at Devonport, where he experimented with his regenerative braking principles and at Southport where he tested his prototype demi-car.



trained drivers. Alfred's name also appears on some of the later patents. From 1905 onwards the chartered patent agent dealing with the applications and based at the same address was John Ernest Raworth. He was J.S. Raworth's nephew, the son of his elder brother Harrison. By 1907 Raworth's younger son, Arthur Basil Raworth, was working with his father as an electrical engineer and his name appears as joint patentee on one of the controller improvement patents in that year. Indeed a family business.

On 1 October 1904 John Smith Raworth registered his own company, Raworth Traction Patents Company Limited, to exploit his existing and future patents in respect of regenerative braking and small efficient tramcars. It was based in offices at 2 Queen Anne's Gate, Westminster. Raworth was joined by his elder son Alfred, who accompanied new car deliveries and

At this time one of the big problems was that the tramway companies run by BET and others were in most cases unable to generate their own electricity, but were forced to buy power from



Top left:
The Raworth K6 controller. This is the type used on the Chester demi-car and some others. The patented slipping ring is about two-thirds of the way down the main drum.

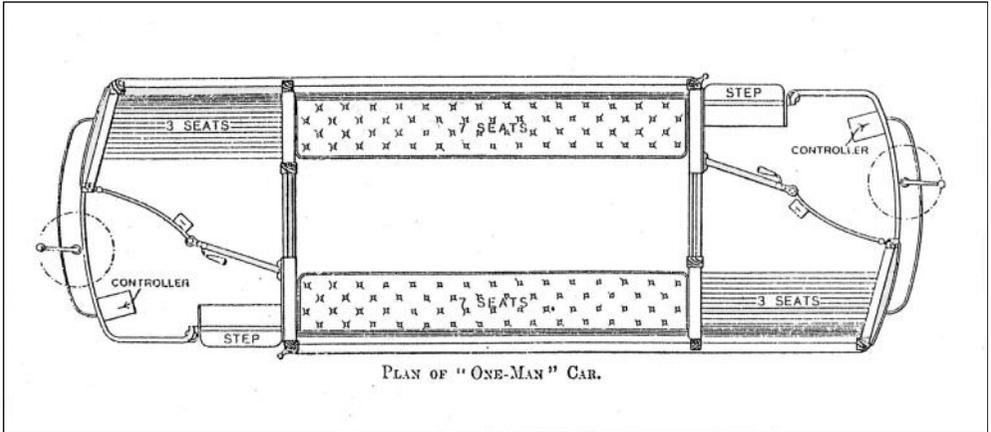
Top right:
The driving position of the Gravesend demi-car. The picture shows the square box controller with its "joy stick" like operation and the vertical handbrake wheel. The safety lifting barrier in the centre of the picture (with handle) which would cut off the power can clearly be seen. *Photo: Tramway & Railway World.*

Above:
This is the lost-motion slip-ring arrangement of Raworth's controller, as extracted from his British patent number 14630 of 1905.

the local authorities at a high price. When an electric motor is coasting it can act as a generator. With rheostatic braking the electricity generated is used up across the car's resistances where it is turned into heat. The work done by the motor slows it

down, hence the braking effect. The principle of regenerative brakes is that by re-arranging the motor connections it is possible to feed this electricity back into the power supply for reuse by other trams so it is not wasted. Raworth's experiments with this were in Devonport in 1902 using two sets of equipment. Later, some 93 sets of equipment were supplied to nine tramways to equip existing conventional tramcars. Two provisional patents were taken out in 1902, replaced in 1903 as we will see.

Raworth's next thoughts went to the tramcar itself. It was clear that on light traffic routes, perhaps in areas which themselves were just developing, something smaller than the normal



This plan, loosely based on the Southport prototype car, appeared in *The Electrician* in 1903. The same drawing is also in Raworth's British patent 2192 of 1903. You can see the lifting barrier to prevent passengers exiting whilst the car is in motion.

double-deck car was required. His design was for a small, lightweight single-deck car with a front entrance/exit. It would use regenerative braking and would be capable of operation by one person. This was the demi-car and the first experimental example was tried in Southport in 1903. It was proved that such a car could be run at around half the cost of a normal tram and so the idea took off.

There are three very significant patents for us, which in fact were taken out by Raworth when he was still in the employ of BET, and to which he gained the rights to free use by a transfer of 3,000 shares in Raworth Traction Patents Co. Ltd. to BET. British patent 3657 of 1903 describes the controller used for regenerative braking as used in the first demi-cars. It was rather like a ship's telegraph in appearance. You pushed the handle forward to accelerate and pulled it back to brake; the joy-stick of its day. Patent 3658 of 1903 explains the design of the motors which were shunt (or compound) wound. Perhaps the most important to this article was patent 2192 of 1903. This actually describes a demi-car. The plan of the tram was in effect the car at Southport. This patent also covers the safety lifting barrier that was used in all Raworth demi-cars. It prevented passengers from leaving the tram while in motion. It was behind the driver. When the barrier was raised, the power would be cut off from the motors. Prior to 1901 Raworth had taken out 48 patents on his various

inventions. There are 17 patents in the period of Raworth's company which directly or indirectly concern the regenerative braking system, controllers and demi-cars plus additional non-tramway related patents.

British patent 14630 of 1905 describes a series-parallel drum controller which was to be used on all the later demi-cars. The actual manufacturer of the first of these devices, called the Raworth R6, is uncertain. The earlier controllers had been built by Brush and the later similar drum controllers were made for Raworth by British Westinghouse and are classified by them as T1R. It has been suggested that they might have come from one of the General Electric subsidiaries. The controller has a lost-motion slip-ring on the main drum so that when the handle is turned anti-clockwise towards the off position it engages different contacts to those used when being turned clockwise towards the full power position. In this way the motor windings can be changed for power or braking.

Raworth's first major set-back came in August 1907 when the Johnson-Lundell Electric Traction Co. Ltd. of Southall, a British subsidiary of an American company and who also had a regenerative braking system for trams (albeit one that had only been tested experimentally in Newcastle in 1902) claimed that Raworth was infringing their patents. Johnson-Lundell had produced electric automobiles with regenerative brakes from the late 1890s. Their tramway re-

generative system was probably superior to Raworth's, but the latter had the commercial success, possibly due to Raworth's numerous trade contacts. Robert Lundell, an American, had British patents 7979 of 1899, 11933 of 1900 and 26668 of 1902, all of which covered aspect of regenerative braking. Johan Gustaf Viktor Lang, a German employed by Johnson-Lundell, had patents 329 and 2564 of 1903 and 176 of 1906 which covered controllers. A long and expensive legal battle ensued with only the lawyers as beneficiaries. Johnson-Lundell had to mortgage its works to cover the legal costs and was forced to withdraw the legal action in October 1908, effectively going out of business. Raworth was also badly hit and relocated from his expensive offic-

es in Westminster to much cheaper premises at 22 Cooper Street, Manchester.

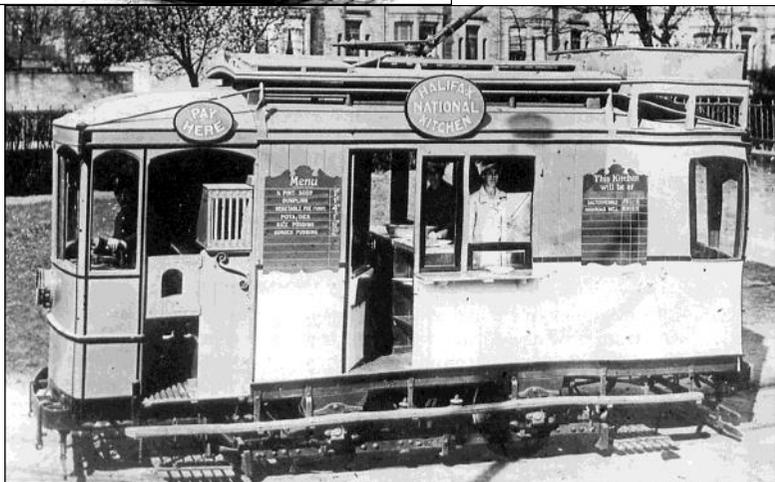
After a few years of continuing sales for Raworth, the worst was yet to come. On 11 November 1911 at 11pm, Rawtenstall tram 14, which was fitted with Raworth's regenerative braking system, ran away on the single track hill in Manchester Road, Accrington, jumped the points at the passing loop and crashed into the waiting car 11 (11 seems the unlucky number in this incident) injuring 20 people. Lt-Colonel Druitt in the Board of Trade report said that the failure was due to a fault in the motor windings which gave the result of the motor running at speed instead of braking, something that could recur. Despite earlier praise for regeneration when he had origi-

nally inspected it, he gave his opinion that regenerative cars were less suitable for use on hills than ordinary trams, a somewhat sweeping and inaccurate statement, but one which was the kiss of death to the Raworth system. The equipment was subsequently removed from trams, including the demi-cars. Seeing the writing on the wall for future sales, Raworth decided voluntarily to wind up his company at the end of 1911, the board's final meeting taking place on 14 January 1913.



Above: Started by BEC but finished by Brush at the end of 1904 were Halifax cars 95 and 96. Initially they were two-window versions similar to those at Gravesend, but 96 was converted to a crossbench car in 1906 as seen here.

Right: In 1918 Halifax 95 was converted into this mobile kitchen. At one stage it was rebuilt into a three-window car.



Two-window tramscars

The early Raworth demi-cars had two side windows in the saloons. If you are working from the Majestic kit, these are unsuitable subjects without considerable modification. The first car of all was Southport 21. Built in 1903 by Brush, it served as the prototype for Raworth's experiments. As with all his demi-cars, it was fitted with regenerative braking and had the patent barrier to cut off power when passengers exited. In service, the rear (off-side) entrance would be closed off by a gate and the folding step would be raised. This car had only half the front enclosed, protecting the three passengers on a longitudinal "smokers" seat on the platform but not the driver. This car also had only one motor, all other demi-cars had two. It ran until 1918. Next came a production run from Brush in 1904 of two cars, 9 and 10, for the Gravesend & Northfleet Electric Tramways. These established the pattern of enclosed vestibules and clerestory roofs common to the other demi-cars. They were withdrawn in 1921. In 1904 Glossop 8 was supplied by the British Electric Car Co. (BEC) to a design (as supplied by Raworth) similar to the Gravesend cars but with an unusual BEC custom made truck of 6ft wheelbase. It lasted until the mid 1920s.

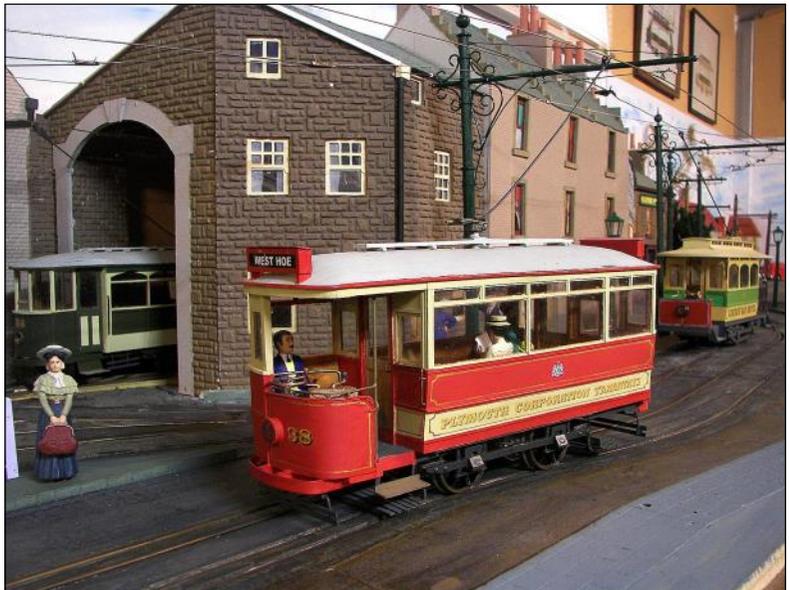
Finally in this early series of two-window cars were 95 and 96 for Halifax. Delivered in the autumn of 1904, they were built by BEC but finished by Brush as BEC had gone into voluntary liquidation in December 1903. They had quite a varied career. On 14 October 1904, while descending the 1:14 gradient in Horton Street,

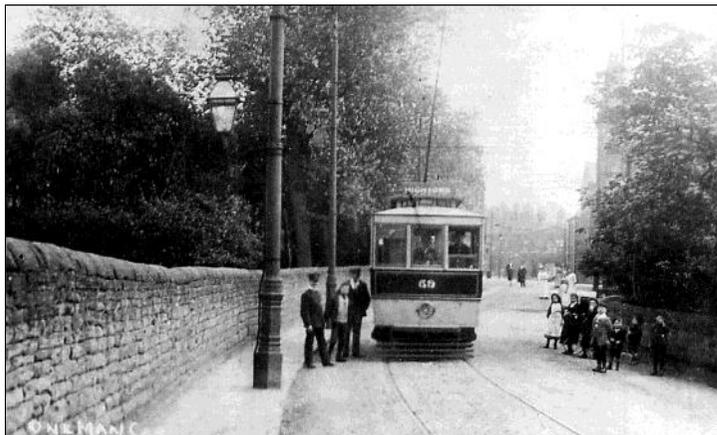
The "odd ones out" were the six Plymouth cars of 1906 which reverted to the two-window and half vestibule style of the Southport prototype but without a clerestory. Here is car 38 represented in 1:24 scale model form.

Model and photo.: Tony Cooke.

car 95 ran away and collided with car 96. Two people were hurt, including the driver of 95. Although both cars were repaired, the Board of Trade inspector, Lt-Colonel Druitt, stated that the brakes had failed as the circuit breaker at the power station had opened. With nowhere for the generated current to go, there is no braking effect. He blamed the Halifax management for poor instruction, as there was an emergency braking system on the tram but the driver was not aware of the correct way to engage it. Around 1910 both trams were converted into open-sided crossbench cars. Somewhat later, 95 was rebuilt again with a three-window saloon and, later still in 1918, into a mobile kitchen, both conditions making it suitable for modelling with the Majestic kit with a bit of work. Both cars were later used as works cars and were scrapped in 1926.

There was one other group of six different two-window cars, 37-42 built by Brush for Plymouth in 1906. They had the half vestibules as with the original Southport car, but no clerestory. They had standard Brush AA trucks. They were withdrawn in 1924, but 42 had become a welding car in 1922 and survived until after the tramway closed in 1945.

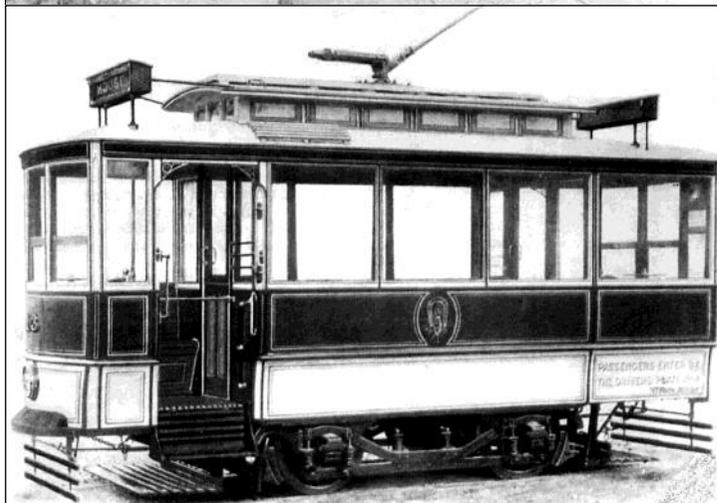




Top:
Started by BEC and finished by Brush in February 1905, Yorkshire Woollen District 59 was the first demi-car built with three side windows in the saloon. The tram was soon transferred to Barnsley where it became car 13.

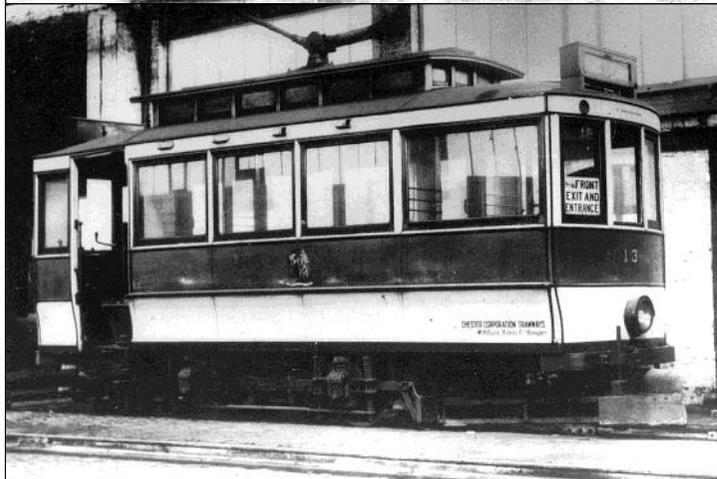
Middle:
Again started by BEC and finished by Brush in 1905 were three-window cars 13 and 14 for Barrow-in-Furness. This is car 13.

Bottom:
To what had now become the standard design, this is Chester 13 built in 1905 by Brush and was very slightly bigger than the previous cars.



Three-window tramcars

From 1905 the Raworth cars were built with three windows in the saloon. It is these trams which can be most easily built using the Majestic kit. Straight out of the box, the kit makes up as the Chester car, but it was always considered that it could be used for the other versions. Prototypes were a mixture of standard and narrow gauges, but in the inaccurate 00 scale it makes little difference. As there are minor detail differences in the body construction and trucks, it is best to obtain a good photograph of the tram you intend to model. In the case of the Erith cars, this may be impossible as no such photographs are currently known to exist, so a bit of imagination will be necessary.



Top:

In 1905/6 Milnes Voss supplied three Raworth demi-cars to Darwen. This manufacturer's view is probably of car 15.

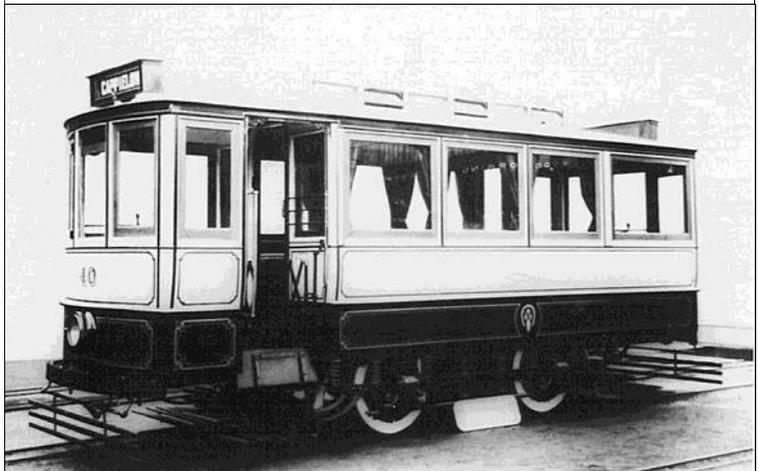
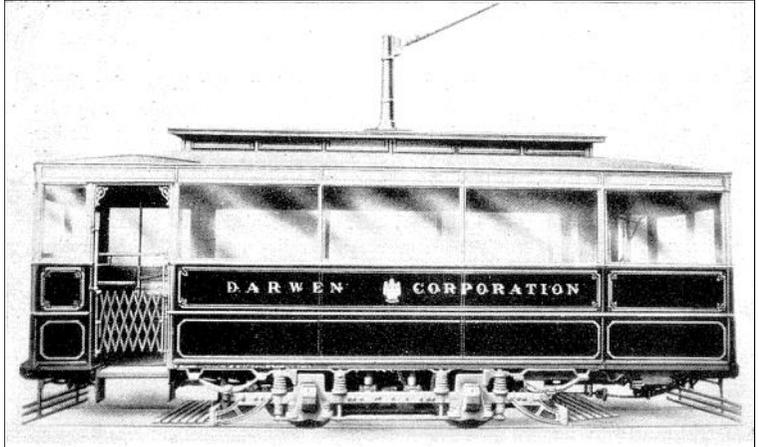
Middle:

In 1908 the Greenock & Port Glasgow Tramways bought car 40 from the United Electric Car Company. It was later sold to Rothesay to become their car 21 and later still was cut down to an open toastrack.

Bottom:

A 1/16 scale model of 1906 Erith demi-car 15 built by the late Richard Elliott in 1976. This model is on view at Erith Library

Photo: Bob Appleton



The table on p.9 gives details of all the trams, including the Halifax options, that could be built from the kit.

Demi-cars that can be built from the Majestic Trams 00 Kit

| System | Date Built/ Bought | Car Numbers | Livery | Date Scrapped/ Sold | Body Builder | Truck |
|----------------------------|-----------------------|-------------|-----------------------------|------------------------|---------------------------------|-----------|
| Halifax* | 1904 | 95/96 | Pale blue/white | 1926 | BEC | BEC |
| Barrow | 1905 | 13/14 | Maroon/cream | 1920 | BEC | BEC |
| Yorkshire Woollen District | 1905 | 59 | Crimson lake/cream | 1905 | BEC | BEC |
| Barnsley | 1905 | 13 | BET Green/white | mid 1920s | From Yorkshire Woollen District | |
| Chester | 1905 | 13 | Light apple green/ivory | 1930 | Brush | Brush |
| Darwen | 1905/6 | 15-17 | Vermillion/cream | c.1920 | Milnes Voss | M&G 21EM |
| Erith | 1906 | 15/16 | Apple green/primrose yellow | 1916/17 | Milnes Voss | M&G 40 |
| Dartford | 1916 | 13 | Maroon/cream | 1917 | From Erith | |
| Doncaster | 1917 | 37 | Maroon/cream | c.1920 | From Erith | |
| Greenock | 1908 | 40 | Dark red/cream | c.1916 | UEC | Brill 21E |
| Rothsay+ | c.1916 | 21 | Maroon/cream | 1936 | From Greenock | |
| Maidstone | 1909 | 16 | Golden ochre/ off white | 1928 | UEC | M&G 21EM |

* The kit is unsuitable for the Halifax cars as built new because they were 'two-window', but could be used for 95 as rebuilt to 'three-window' or, with heavy modification, as the mobile kitchen car.

+ The Rothsay car was modified to an open toast-rack c.1920

Abbreviations

BEC - British Electric Car Co. Ltd., Trafford Park, Manchester

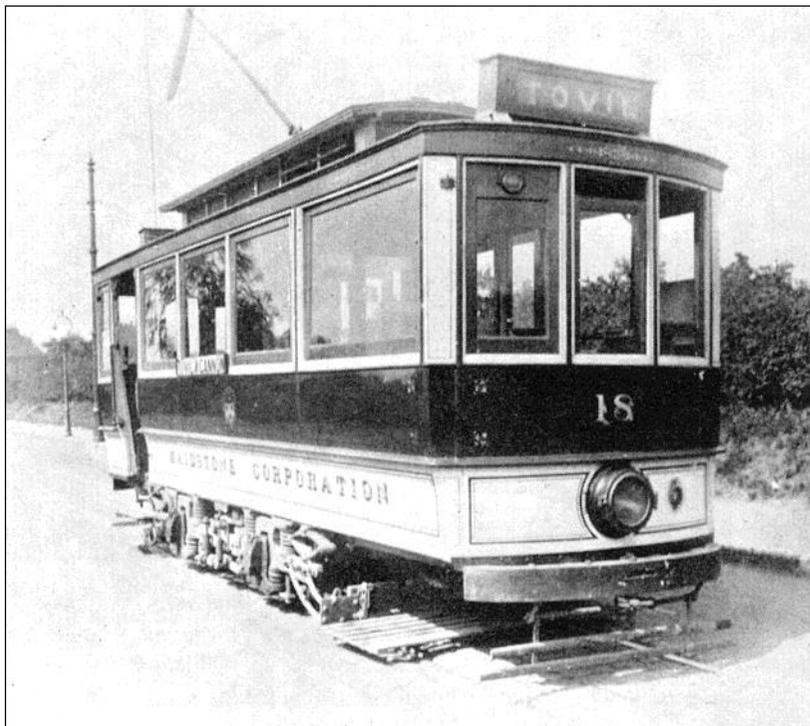
Brill - The J.G.Brill Company of Philadelphia, USA

Brush - Brush Electrical Engineering Co. Ltd., Loughborough

M&G - Mountain & Gibson Ltd., Bury, Lancashire

Milnes Voss - G.C.Milnes, Voss & Co. Ltd., Birkenhead

UEC - United Electric Car Co. Ltd., Birkenhead



Left:
The final Raworth
demi-car was
Maidstone 18 of
1909. It was built
by UEC. It is
seen here at
Tovil.

Below:
Maidstone 18 in
OO scale made
from the Majestic
Trams kit with a
few minor modifi-
cations.

Model and photo,
John Prentice.



After Raworth

The Maidstone car was a surprising survivor and was used until 1970 on a lorry chassis as a weekend bungalow, ultimately at Winchelsea Beach. It was recovered for preservation and eventually found its way to the Dover Transport Museum. Sadly a few years ago it was considered beyond restoration and was broken up, a terrible loss of such a unique relic from tramway history.

It is worth noting here that there were a few similar small single-deck non-Raworth equipped cars, sometimes called demi-cars, (quite different from the Majestic kit). In most cases they were cut down and modified for one-person operation from existing trams. Such vehicles ran for a while in Lancaster, Manchester, Warrington, Southampton, Glasgow, Ayr, Gravesend and York. That for York was built new in 1925 by English Electric and was reminiscent of the later Raworth cars but without a clerestory.

We should also briefly consider the American Birney Safety Car. This had most of the features of the Raworth demi-car other than the regenerative brakes. It was lightweight and on a four-wheel truck (the Brill 78E or later 79E). It was

operated by one person and its doors were interlocked with the car's brakes and power, just as with the Raworth lifting barrier (hence safety car - a feature first patented by Joseph M. Rosenbury in 1915). It was half the size of a conventional American bogie streetcar and was designed for light traffic and to operate cheaply. Originating from pre-war ideas by Charles O. Birney, the design came into common use after the First World War to help combat competition from the automobile, and was produced in huge numbers until the mid-1920s. It was developed by the American Car Company, a J.G.Brill subsidiary, and they with other Brill subsidiaries went on to build some 4000 trams. Other US and Canadian manufacturers built a further 1700, quantities Raworth could not have even dreamt of. Was Birney influenced by Raworth? Hard to tell, but three US patents filed by him in 1908 (908199, 912792 and 924420) cover different methods of controlling passengers of "cars using the pay-on-platform principle" from which his Birney car seems to originate (later patents also apply). This was just after the time when Raworth would have been receiving the maximum publicity for his demi-cars in the trade press, so



From the Corgi Vintage Bus Lines range, this is a Birney Safety Car in 1:48 scale (American 0 gauge). The similarity between this general tram design and the Raworth demi-car is notable and is discussed in the main article.

it is possible that Birney knew about them.

Ironically, C.J. Spencer of the Underground Group visited the US in 1919, saw the Birney cars, and as a result ordered the conversion of Metropolitan Electric Tramways single-deck car 132 in 1923 to have a smaller saloon, longer platforms and a front entrance, thus resembling a demi-car. It became London United Tramways 341 and at first was tested on the Richmond - Tolworth via Kingston route, then entered service on the Brentford (Half Acre) - Hanwell shuttle service. Three, somewhat larger, one-man bogie cars with front entrances and rear exits followed in 1924. At this time, 341 was given bogies and the body modified although retaining its front entrance, but was no longer much like a demi-car. They were all withdrawn in 1928.

John Smith Raworth was a man whose ideas were clearly well ahead of his time. It is a pity

that regenerative braking was so closely wedded to his demi-car. The lack of confidence in regeneration by many operators limited the sale of the trams and in the end its discrediting brought about the end of their production. However, we are left with an excellent subject for modelling.

For those requiring an in-depth description of the principles of regenerative braking on these and other more modern vehicles, I suggest consulting *The Regenerative Braking Story*, by Struan J T Robertson and John D Markham. For more on Raworth there was a series of articles by Ian Yearsley in *Tramway Review* nos. 76 to 78 in 1975/6. I acknowledge the use of both these references, together with British and US patent documents and other miscellaneous sources for the writing of this article. Unless otherwise stated, the illustrations are from the author's collection or the TLRS archive.

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