The History of The Escalator

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Abstract

In 1859 Nathan Ames registered the first patent for an escalator. He was ahead of his time as the first production electric motors didn't arrive until the 1870s. His efforts were followed in the late 1880s by Seeburger, Reno, Halle, Wheeler, and Dodge. Escalator was a name coined by Seeburger being a combination of scala (steps) and elevatus (to raise). At one stage Otis had the monopoly of the escalator industry and was the only company allowed to spell escalator with a capital "E". In 1911, London Underground installed its first escalator. The fascinating history of escalators is looked at from its invention in 1859 to the present day.

1.0 INTRODUCTION

Six men and their individual engineering abilities have created the escalator as we know it today:

- Nathan Ames
- Jesse Wilford Reno
- Jacques Halle
- Charles Seeburger
- George Wheeler
- James M Dodge

The escalator, which carries millions of people billions of miles every year, was first conceived in 1859 long before the widespread availability of electricity. Very few people, including those within the escalator industry itself, know the fascinating history of these machines and this paper is intended to give you a brief insight into the development of the escalator from its embryonic stage in the late 1800's through to the more recent introduction of the compact machine.

Charles Seeburger first coined the word escalator. It is reputed to be a combination of the Latin terms "scala" (steps) and "Elevatus" (to raise). But when he tried, in 1895, to patent his invention under that name he was told by the patent office that the application could not be filed as there was no classification for that title. So it was granted under the title "elevator". He eventually registered the name "escalator" as a trade mark in 1900.

2.0 THE FIRST PATENT

The first recorded patent was issued to a gentleman called Nathan Ames on August 9th 1859. The patent was an American issue numbered 25076 and was entitled "revolving stairs". The

arrangement proposed took the form of an equilateral triangle of steps whereby a passenger rode up on one side and stepped off at the top , or would step on at the top and ride down the other side. Returning steps would move horizontally across the bottom. As far as any one can tell this design was never built. Later experience with escalators showed that a good working angle of inclination is 30° to the horizontal, and this would have meant that Ames triangle could not be equilateral as the base would have been extremely long.

The design also had shunt landings which became a major design feature of the later Seeburger machines and even saw use on Otis LHD type machines until the design was withdrawn in 1924. A shunt landing was a design where the passenger had to step off the escalator at the terminal end by a sideways motion rather than straight off as we do today.

The design was probably never built because of the lack of electrical distribution systems and also the fact that there was no need for machines to move large numbers of people at that time. Electricity was a very new concept and, for example, Liverpool (UK) didn't see a distribution system until 1883. The electric motor was still in its infancy as well with Faraday first demonstrating an experimental motor in 1831 but large scale production didn't start until the 1870's. Sadly for Ames he may have been slightly ahead of his time.

3.0 THE GREAT PATENTS RUSH

1892 was obviously a good year for the escalator with three patents being issued, two in the US and one in the UK. Jesse Reno having one issued in both countries.

On 16th April 1892 Reno was granted a UK patent (No 5088) under the heading "Lifts of continuous stairway and like type". The patent made the point that handrails may be omitted and it referred to a speed of 200 ft/min, which is faster than those currently made as standard by the major manufacturers today. It also referred to up and down inclined elevators criss-crossing as in modern stores today. They were, in fact, linked together to balance loads. The design had a combing action at the end of the escalator rather than a shunt design familiar to the Ames & Seeburger design previously described.

On 2nd August 1892 a US patent was issued to George H Wheeler. Although it was for a moving stairway it was registered under the term "elevator". It had power driven handrails, a sideways or shunt landing, and flat topped steps. His patent application showed the possibility of arranging an up and a down running machine behind each other in line so as to form the sides of an Ames style equilateral triangle. He could not raise any interest in his idea and in 1898 he sold his patent to Charles A. Seeburger who had already been working on ideas of his own.

Staying with 1892 a US patent (No 470,918) was issued to Jesse W. Reno. The patent was for a "endless conveyor or elevator". It had a treadway made up of sections four inches deep in the running direction, and 20 inches wide. These were hinged together. Each section had nine cleats spaced one and a quarter inches apart and Reno recommended that these be manufactured using cast iron. His later developments introduced wooden replaceable cleats and rubber facings. His original design had these tread sections flat to the feet, just like any other belt conveyor, but later improvements included a wedge profile applied to groups of three slats, lower at the leading one and higher at the trailing one of the three. This was to

provide a better grip for feet during the upward journey. Originally they were used to move people upwards but certainly by 1903 they were working in the opposite direction as well.

In 1897 two new names came onto the scene with US patent (No 598,772) being issued to James M Dodge and a UK patent (No 19,803) being issued to Jacques Halle, a Frenchman.

In 1899 George Wheeler of New York who had been awarded a patent in 1892 assigned one half of it to a Charles Seeburger, a man who was to become well known in the escalator industry.

In 1899 Reno was issued yet another patent (No 637,526), followed by No 673,890 on 14th May 1901, No 804,266 on 14th November 1905 and No 817,338 on 10th April 1906.

By 1906 Reno had patented a form of step which had the top surface of the step horizontal. He also registered a common drive arrangement to be placed between a down and an up machine. This idea was resurrected by O&K in the 1970's.

Reno kept going and in 1910 was issued yet another patent (No 963,176)

Reno's arch rival, Charles Seeburger was issued a patent (No 999,885) on 8th August 1911 but not to be outdone Reno was issued patent no 1,112,836 on 6th October 1914, No 1,178,102 on 4th April 1916 and No 1,288,196 on 17th December 1918.

Reno and Seeburger were certainly making their name in the market place!

4.0 INSTALLATION OF THE FIRST MACHINES

The first escalator and moving walkway installations were built as pleasure rides rather than as serious devices to move passengers but new installations occurred as fast as patents were being issued.

In 1892/3 a moving stairway was installed at the World Fair Ground, Chicago, USA for the Colombian Exposition. It consisted of a 900 foot long oval shaped track with an inner and outer track. The outer track ran at 3 mph and the inner 6 mph. The walkway was supported by closely coupled railway trucks each driven by their own electric motor.

In 1895/6 Reno sold one of his inclined elevators for use as an amusement ride at Coney Island, USA. It started operation in the September of that year at The Old Iron Pier and carried an estimated 75,000 people before being dismantled. Dismantling did not spell the end though, it was re-erected in 1897 at the New York end of the Brooklyn Bridge. It had a vertical rise of 7 ft and was recorded to be 25 degrees to the horizontal. It had a step width of twenty inches and ran at about 75 feet per minute. According to some records the machine had a capacity of 3,000 people per hour which meant that the step speed would have been some 0.4 m/s.

In 1896 Reno sold four escalators to the Siegal Cooper Department Store in New York, USA on the corner of 6th Avenue and 19th Street.

Having purchased 50% of the Wheeler patent in 1898 followed by a complete buyout, Seeburger signed a manufacturing agreement with the Otis Elevator Company and in 1899 Seeburger and Otis designed and manufactured the first two step type escalators. One was installed at the 1900 Paris Exposition and was later sold to the Gimbels Department store in Philadelphia where it continued to run until 1939, some reports suggest as late as 1946. The second was sold to a Chicago Department store.

In 1898 Harrods in London installed a demonstration machine for intending purchasers! Buying an escalator from a department store seems a somewhat strange method of procurement. What Harrods had actually purchased was the Jacques Halle patent of 1897.

In 1898 a Reno inclined elevator was installed in Bloomingdale Brothers Department store, 3rd Avenue, New York, USA. Another machine (of unknown manufacture) was installed in the Louvre in Paris at the same time

In 1899 a Reno machine was installed at the Crystal Palace Exhibition in London. This particular machine inspired W P Dempsey's musical hall song "Up the sliding stairs". It is reputed that a charge of 1d was levied to ride the escalator.

1899 also saw Seeburger join forces with Otis.

In 1900 Seeburger installed one of his machines in Simpsons Crawfords department store, New York.

Reno's commercial success continued and in 1900 the Manhattan Elevated Railroad of New York City ordered 100 inclined elevators and the last one of these remained in service until the 3rd avenue elevated line was removed in 1955. The first machines, a pair, were installed at the 59th street station.

Reno was not the only one to be successful with customers in the railway sector, a Seeburger escalator was installed during 1900 at the 23rd Street station of the New York Elevated Railroads 6th Avenue Line.

In 1900 the Paris Exposition took place. As has already been said, one of the Seeburger/Otis designs was installed for this but Reno was also present at Paris and is reputed to have had five machines there, although some reports state two. These were apparently sold to a number of New York and Philadelphia department stores after the Exposition. One of the Reno machines was reputed to have been a moving walkway of a pallett type with a slow and a fast walkway. A step type machine was also exhibited in Paris:

In 1901 the first Reno inclined elevator to be erected at a British Railway Station went into service at Seaforth Sands Railway Station on the Liverpool Overhead Railway. It was reputed to have been removed in 1906 when the station was rebuilt. The reason for removal was rumoured to be the number of complaints from women getting their skirts caught in the mechanism.

In 1902, and possibly spurred on by the 1901 sale of the Seeburger/Otis escalator to Gimbels of Philadelphia, Maceys of New York City installed a bank of four escalators. Maceys went

on to extend the arrangement to the fourth floor in later years. Later reports indicate that the escalators were still working in the 1950's.

In 1903 a Boston Store, Whites, order 10 escalators - 5 up and 5 down.

In 1905 the Wood Worsted Mills in Lawrence, Massachusetts ordered four escalators. It is reputed that these were the first ever reversible escalators. They were installed for the use of employees arriving and then leaving their shifts.

In 1906 a Seeburger escalator became the first subway (underground railway) installation at New York's Bowery Station on Delancy Street (some reports say 1909). 1906 also saw the first escalator installation in Germany at The Wertheim Store, Berlin.

1906 saw another unique installation for underground stations when Reno installed his spiral escalator at London Underground's Holloway Road Station. The station still exists and is on the Piccadilly Line however in those days it was The Great Northern, Piccadilly and Brompton Railway. The stairway was continuos and ran in a clockwise direction. The inner spiral was the ascending stairway and the outer spiral the descending. The shaft diameter was 23 foot and had a rise of 35 ft. Unfortunately the device didn't last very long and was removed in 1911. According to the Underground Internal Press The Board of Trade was not convinced as to the safety of the machine. Recent documentation from London Underground advises that this piece of history may well not have been lost and that some of the structure still remains despite a contract having been issued in 1911 to dispose of it.

In 1910, Seeburger, who had had an agreement with Otis Elevator Co. for his escalator since 1899, finally sold all his patent rights to Otis. The escalator trademark then also transferred to Otis and it remained their property until 1950 when it was deemed to have become a generic title and therefore in the public domain. The big players in the market place were now Otis and Reno.

4th October 1911 saw the acceptance and open for public running of the first Seeburger A type machine at Earls Court Station. This machine should not be confused with the machine, probably by Otis, which was installed as a Coronation Year novelty at the Earls Court Exhibition which is reported as being the catalyst for the London Underground installation.
A further 20 machines had been installed at nine other stations by 1915. The final machines were installed at Maida Vale in 1915. They were all Seeburger A type machines with flat step surfaces and side shunt exits at the landings. The early shunt design was retained by the early Otis LHD machines at Moorgate and Shepherds Bush. The shunt landings came in two forms, some were one exit to the side and some were dual exited with a triangular bollard type obstruction allow exit on either side. Later machines, as a safety precaution, had an added safety feature of a moving skirt guard belt. The first of the cleated escalators without Shunt Landings entered service at Clapham Common Station in 1924. The last original Seeburger A type design was removed from the Broad Street entrance of Liverpool Street Station in 1953 after a service life of some 40 years. The A type escalators were installed to an angle of 26 degrees 23 minutes, an odd angle but they were made as a run on to a German order to this angle. Because of the totally new concept and the hesitance of the general public London Underground employed a man with an artificial leg by the name of "Bumper Harris" to ride the escalators to create confidence. In a 1982 letter from a member of his family who had undertaken some research, it was revealed that he only rode the escalators for the first day

1916 saw Otis install their first office environment escalator in the Union Arcade Building in Philadelphia.

5.0 OTIS TAKE OVER THE MARKET PLACE

In 1899 Otis improved the plans of Charles Seeburger and thus designed and built the worlds first true escalator in the sense of what we now know to be an escalator. Otis spent $30,000 for research and development, a phenomenal cost for 1899. In the same year they built the first Seeburger Escalator at their Yonkers factory, New York. This machine was subsequently sold to a Chicago department store. The second escalator was exhibited at the Paris Exposition of 1900, this was the escalator that was eventually sold to Gimbels department store of Philadelphia.

The Otis design from 1903 featured glass balustrades, this followed the 1900 Paris Exhibition where glass balustrades were exhibited with great success. The Reno type from 1903 also featured glass balustrades. The escalator trademark transferred to Otis when it took over Seeburger officially in 1910 and it remained their property until 1950 when it was deemed to have become a generic title and therefore in the public domain. The trademark formally allowed Otis to be the only company to be able to spell escalator with a capital E. Then, in 1911 Otis took over the Reno Electric Stairway and Conveyor Co. Having taken over the two major names within the same number of years Otis now become the only major player in the market place. For a number of years Otis marketed the Reno and the Seeburger machines separately. They marketed the Seeburger machine as the A type and the Reno machine the Duplex Cleat Type. Other companies were prevented from entering the market place until the 1930's when the patents granted to Reno and Seeburger (both owned by Otis) expired.

1927 saw the first escalator in Germany, built by Carl Flohr for the Wertheim Department Store in Berlin. This was based on the Otis design. A year later Carl Flohr (later to become Flohr-Otis) designed the first public transport escalator for Belgium which was installed in the Schelde Tunnel.

In 1932 Otis installed 10 escalators in the 60 Wall Street Tower, New York and also 6 escalators in the RCA Building of the Rockefeller Centre, New York. The latter are of interest because of their offset handrail arrangement.

1938 saw another Otis first. The first sea going escalators were installed aboard the "Nieuw Amsterdam" passenger liner. They had a 9ft rise and served between the kitchen and the dining saloon. 1938 also saw Flohr and Otis enter discussions on merger. This was halted due to the war but was eventually resumed and the merger took place in 1951.

In 1950 Otis responded to their loss of the trademark title "escalator" by registering the name "Escal-aire" which they applied to their glass balustraded escalators. Otis also have the registration mark "Trav-o-lator" in their possession. The generic name in Europe is passenger conveyor and in the USA it is the moving walkway, it looks like this name is, at least, safe.

In 1963 Otis open the Stadthagen complex in Germany which occupies over 40,000 sq. metres and is one of the worlds largest factories producing escalators and passenger conveyors.

1969 saw Otis install the first Trav-o-lators in Europe at the Stockport Shopping Centre, England.

6.0 THE SEEBURGER / RENO DESIGN MERGER

As has already been stated, for a number of years Otis marketed the Reno and the Seeburger machines separately. In 1920 Otis took the decision to merge the best features of each design into a new type of escalator similar in basic design to today's heavy duty machines. These were known as the L type. Outwardly these machines looked very similar to the Seeburger A type machines but incorporated improvements such as twin step band chains. The original L types retained shunt landings but as from 1924, after an experiment at London Underground's Clapham Common Station, comb landings were introduced.

Up until 1920 only 350 escalators of both the Seeburger and Reno design had been sold World Wide, but mainly in North America, United Kingdom, Germany and France. Otis sold more machines in 1921 and 1922 than in the previous 20 years.

The Seeburger A Type

The A type machines were designed for rises of between 28 and 54 ft and were installed in pairs. The down escalator was reversible but this was not the case for the up machines. Consequently the lower landing of an up machine was a conventional balustrade and handrail affair with the upper end having a shunt landing and with both ends of a down machine having shunt landings. The A type was manufactured to an angle of 26 degrees and 23 minutes (compared to today's norm of 30 or 35 degrees). This was simply because the first machine installed was put into a shaft of this angle and rather than change the angle which would have meant additional cost for retooling etc, they simply stuck with it. The steps measured 4 ft by 1 ft 6" with either an 8 or 9 inch riser. The step was simply a four wheeled bogie consisting of 3 hardwood planks supported by bolted castings and mounted on four wheels. The four wheels each had their own track, the track of course determining the profile of the step band. Each step was connected to the step chain which was a single chain running down the centre of the step band and kept in tension by springs and counterweights acting in opposition to each other. The step chain was driven by a bronze rimmed sprocket located near the top of the escalator which also engaged the returning chain. The sprocket was mounted on the main drive shaft and was geared down. The prime mover was 600 volt direct current straight shunt wound motor of between 30 and 50 hp (dependent upon the rise). At the lower end of the escalator (what we would now call the carriage) the step chain returned via an idler sprocket.

An interesting feature of these machines was the fact that they had two motors, one on either side of the gearbox. They were directly coupled to opposite ends of the associated worm shaft and the couplings between each motor and worm shaft were fitted with electrically operated brakes. Only one motor was required to run the escalator with the other one being switched out and acting as a reserve. In a similar fashion only one brake was ever lifted (the one relevant to the motor in service) with the other one being lifted mechanically and being held in reserve.

The balustrading, decking and side panels were all constructed of timber and the side panels were arranged vertically so that a uniform width of just over four foot was maintained between handrail and step level. The handrails were similar to those we know today with layers of rubber and canvas. These were friction driven from the main drive shaft through a countershaft and an intricate system of bevel gears. An unusual feature of the hand rail arrangement, as compared with later machines, was the twisting of the handrail through 90° to provide support along the shunt end.

The electrical control equipment was located in the machine room and to start these escalators one switch was operated and this effected a resistance start by a solenoid moving over a number of resistance steps. This was the only point from which the escalator could be started, there were no key switches like we are used to today.

A number of safety devices were incorporated into the design. This included double braking on the worm shaft, either of which could be used when required. A non reversing device was also fitted. This was essentially a ratchet arrangement and was fitted on the up machines to prevent them being reversed. A broken step chain device was also incorporated to stop the steps in the event of a chain breakage. Emergency stop switches, for use by passengers, were installed on the balustrades at a later stage.

Seeburger machines were rated at 100 foot per minute.

The Reno Machine

The Reno escalators had solid rubber handrails with chains inside them that were guided along the decking by a lubricated steel channel. Unfortunately this system often spoiled passengers clothing. Another feature was the 12-16" combs which meshed with the inclined cleats of the steps but in reality the Reno type was actually an angled conveyor rated at 80 feet per minute. It did have twin step chains which along with the comb arrangement was imported into the new L type.

1922 saw the installation of the last true Reno type escalator.

The Combination or L type Machine

Otis were still the only company manufacturing escalators. As the market was moving very slowly they took the radical decision to completely redesign the machine incorporating the best features of both the Reno and Seeburger types.

The comb plate type was opted for thus seeing the end of the shunt landing.

Steps were selected as the preferred option rather than an inclined conveyor design.

The Reno and Seeburger machines ran at 80 and 100 feet per minute respectively. Otis decided to settle for 90 foot per minute as a standard. In 1974 Otis still used standard speeds of 90 foot per minute for store type escalators and 120 foot per minute for mass transit systems.

Twin step chains were selected.

7.0 DESIGN CHANGES IN THE 1930'S

1930 was the year that the word escalator appeared in the American A17.1 safety code for the first time.

In 1938 Otis introduced the close cleated metal step tread. This enabled the clearance between the combs and the step treads to be obtained. The new design had 105 cleats per step whereas older machines had 29 parallel cleats and were made of maple wood which was reputed top be difficult to split and was virtually fireproof.

8.0 LONDON UNDERGROUND

The combination machines known as the L type were installed on LUL. These had an inching facility to allow the engineer to move the step band slowly and under his command and a non reversing switch to prevent an upward running machine running backwards. This switch would trip the pawl brake in the event of a run back. A broken chain switch to stop the escalator in the event of either step chain breaking and a pawl brake unit on the main drive shaft, with an electrically released pawl stop, which worked in conjunction with other safety devices were also fitted.

Many years after these machines were installed on LUL they were fitted with speed ray equipment to allow the step chain speed to be reduced to 50 foot per minute when the escalator was not occupied by passengers. The first speedray installation was at Manor House in 1934, but by 1956 only 11 more escalators had been equipped. In that year a simpler form of control was available and, after a trial at Baker Street proved successful further machines were converted.

1937 saw the introduction of a new escalator at Kilburn Station with Zinc Alloy cleated step treads.

Between 1935 and 1938 the Seeburger A machines were converted to MA types. The last original Seeburger A type design was removed from the Broad Street entrance of Liverpool Street Station in 1953 after a service life of some 40 years.

1944 was the year that Billy Brown, the irritating but official propagandist entered the London Underground scene. He voiced his opinion that "Here is another bright suggestion, standing right avoids congestion". Later in 1944 stand on the right banners were erected at Kings Cross, Piccadilly Circus and Waterloo stations.

In 1955 London Underground purchased a J&E Hall machine which was installed at Alperton Station. This was the first London Underground machine not to have been of Otis origin. This machine was originally exhibited in "The Dome of Discovery" at the South Bank Festival of Britain Celebrations. It was finally withdrawn from service in 1988.

1971 saw a departure from tradition with an Eggars & Kehrmahn machine installed at Old Street Station.

In 1983 London Underground broke tradition again and placed an order with W&C Pantin to develop an escalator for their needs. The prototype, destined for Manor House, was commissioned in 1987. By the time of commissioning Pantins had been taken over by APV Baker.

1983 also saw CNIM enter the London Underground market place. Two machines were installed at Kentish Town. CNIM went quiet between 1983 and 1989 but made up for it with two machines at Kings Cross and six more, including the highest rise on the Underground System, at Angel station in 1992.

9.0 HISTORY FOR THE WRONG REASONS

On Christmas Eve 1944 London Underground suffered a major escalator fire at Paddington Station (Bakerloo Line). The escalators were gutted. Between 1939 and 1944 77 escalator fires had been experienced by London Underground.

The Times reported on 12th August 1954 that a man was fined for sliding down the handrail of an escalator. Said by prosecuting counsel to have been in high spirits after getting married, Stuart Parker of Balham, was fined 10 shillings at Bow Street Magistrates Court, London on 11th August 1954. He had pleaded guilty by letter to sliding down the handrail at Leicester Square Station.

November 18th 1987 saw the worst escalator accident in history when a fire under a bank of three escalators at Kings Cross Station resulted in the death of 31 people including one fireman.

On June 18th 1994, 43 people were injured and 28 persons were hospitalised when an escalator malfunctioned and sent dozens of baseball fans tumbling backwards at Camdens Yards Baseball Ground, USA. Witnesses reported a loud cracking noise prior to the reversal of the step band.

Author Biographical Details

David Cooper is the managing director of LECS (UK) Ltd. Prior to this he was a district engineer surveyor with British Engine Insurance and wrote and presented their technical training manuals and courses on lifts and escalators. He is currently chairman of the Chartered Institute of Building Services Engineers Lift Group Committee (elected 1996) as well as being a UK Co-ordinator of The International Association of Elevator Engineers. He has presented many papers at home and abroad to a wide range of organisations including CIBSE at their 1993 Lift group Seminar and the IAEE in Vienna 1993, Barcelona 1996, and London 1997. David writes a regular column on lift and escalator safety in the UK trade journal Elevation, and has written many papers for trade journals including Elevatori, Elevator World and Lift Report. In 1997 he was a co-author of a book entitled Elevator & Escalator Micropedia with Dr George Barney and John Inglis and published by The International Association of Elevator Engineers.