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FRANK SPRAGUE

The Father of Electric Traction

by David Cousins

Frank Julian Sprague trained in the United States Navy becoming an officer and inventor in the field of electric motors, electric railways, and electric elevators.

The name Frank Julian Sprague may not be as well known to most of us as Richard Trevithick or George Stephenson in transportation or as Thomas Edison or Alexander Bell in the development of electrical apparatus, but Sprague played a significant role in the development of electric motors and control apparatus for railway transportation systems and elevators.

Figure 1 Frank J Sprague

Sprague was born in Midford, Connecticut in 1857 and whilst at school showed a natural aptitude in several subjects including chemistry, mathematics and physics. Upon leaving high school he studied at the United States Annapolis Naval Academy becoming a midshipman in 1874. His time at the Academy gave him a sound training to become an electrical engineer and he developed an interest in innovation and invention. He served in several ships of the United States Navy and whilst on the USS Minnesota his interest in electric motors and dynamos led to him inventing the inverted type of dynamo that had an arrangement of field and armature circuits that became a basic principle of all series-parallel controllers used on direct current railway motors. in 1881, he filed for his first patent on his innovation that he called the 'Dynamo Electric

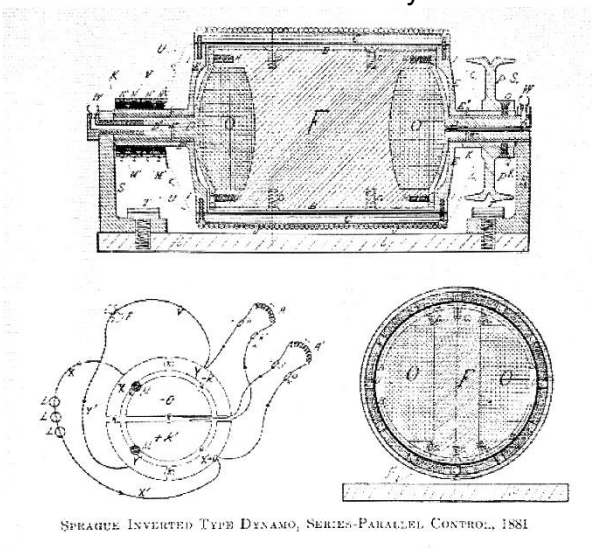

Figure 2 Sprague Inverted Type Dynamo

Machine'. He had planned to show it at the Paris Electrical Exhibition, but this was turned down. On another ship in the same year, the USS Lancaster, he installed the first electrical call bell system in the U.S. Navy.

In 1882, whilst on three months leave to attend the Paris Electrical Exhibition and the Crystal Palace Exhibition in England, he served as secretary of the jury awards for gas engines dynamos and lamps. His visit to England was an important, on two counts, firstly, whilst at Crystal Palace he had an

unplanned meeting with Edward Johnston a business associate of Thomas Edison who he impressed and secondly, he took the opportunity to travel on the London Underground system, the first of its type in the world when it opened in 1863. Whilst electricity was used for lighting, it used steam locomotives for propulsion of trains resulting in poor air quality for passengers and staff due to smoke filled stations and carriages. The methods of accessing station platforms from ground level for passengers were not the best and this would become more of a problem with Underground tunnels getting even deeper. Sprague recognised that electric propulsion and associated systems for transportation was the better way forward in the future.

Back in America Johnson introduced Sprague to Thomas Edison and persuaded him to resign from the Navy, which he did in 1883 to become a technical assistant to Edison. Whilst Edison was used to the 'try and try' again technique, Sprague favoured mathematical methods for solving problems. In his short period working for Edison, he assisted in the installation and operation of Edison's Pioneer three wire electric light systems and, redesigning and correcting the Edison system of mains and feeders from central station distribution. He developed a formula for determining the ratio of wire size to current. After working for Edison for a year he was concerned that Edison would take much of the credit for his ideas and that his own interests were in a different direction.

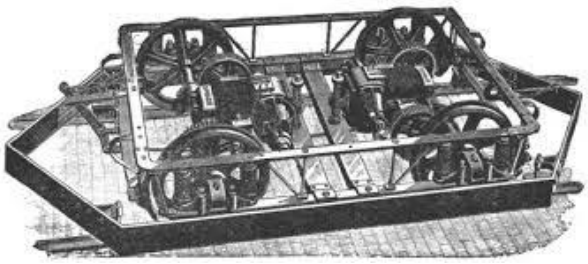

Figure 3 Sprague improved electric motor truck

Sprague's interest was primarily in electric traction for transportation rather than that of Edison who was more interested in lighting systems and he subsequently set up his own business in 1884 called the Sprague Electric Railway and Motor Company. Until the mid-nineteenth century most city transport was horse drawn and these were gradually replaced by horse drawn carriages and wagons on rails.

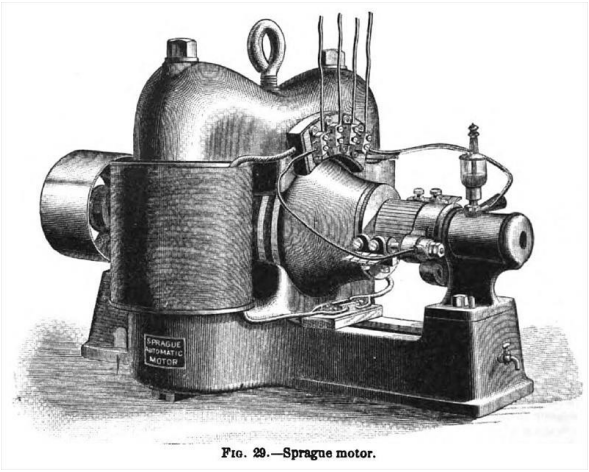

FIG. 29.—Sprague motor.

Figure 4 The Sprague Motor

His innovations included the constant speed non-sparking motor with fixed brushes, the first motor to maintain constant revolutions per minute and different loads. He showed his equipment at the Franklin Institute's electrical exhibition in Philadelphia resulting in 250 motors being sold in two years. In 1885 Edison Electric Light Company officially endorsed the motor in a letter sent to its local companies. Sprague then moved on to design a method to regenerate power that would be returned to the main power supply system during de-acceleration and braking thus providing greater economy. He also developed a distorted system of compound field magnet winding that maintained a fixed non-sparking position of commutator brushes and a three-point wheelbarrow suspension of axle mounting geared motors for electric railways was soon used universally for trolley car equipment.

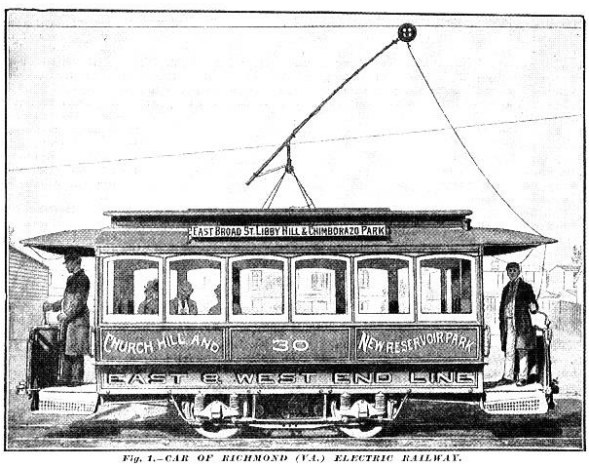

Fig. 1.—CAR OF RICHMOND (VA.) ELECTRIC RAILWAY.

Figure 5 A Sprague electric street car on Richmond Union Railway 1888

Subsequently many of his inventions and innovations that his company developed were installed on the 12-mile electric railway of the Richmond Union Passenger Railway between 1887-1888. This was the first large-scale electric trolley line in the world. Over the following years many more electric railway systems were built using overhead catenary systems in America and many other countries.

In 1890, the Edison General Electric company that manufactured equipment for Sprague purchased the Sprague Electric Railway and Motor Company. By 1889 Sprague turned his attention to the field of vertical transportation – electric elevators. He thought that with the electrification of streetcars and the resulting increase in passenger numbers and speed that by providing an alternative means to move passengers was needed.

In 1892 Sprague with Charles Pratt developed Sprague-Pratt electric elevator, the company founded was called this Sprague Electric Elevator Company. The elevator they developed was faster and was able to carry larger loads than the hydraulic and steam elevators currently in use at the time. Elevators were sold around the world and after supplying nearly 600 units, the company was sold to the Otis Elevator Co. in 1895.

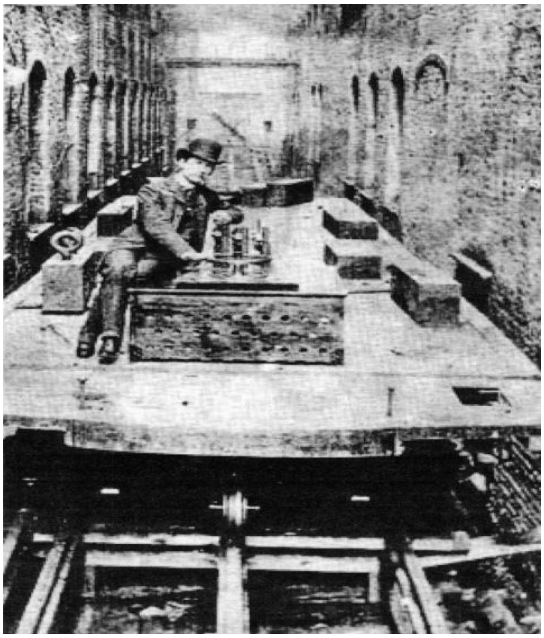

Figure 6 Test railway car set up by Sprague in 1888

His experience with elevator controls led him to subsequently devise a multiple unit system of electric railway operation which accelerated development of electric traction. In this system, each car of the train carries electric traction motors. The traction motors can all be controlled by the driver using a system of relays and interlinking wires. For lighter trains there was no need for a separate locomotive thus saving capital expense and each car in the train can generate revenue. Where locomotives are used one operator can control all of them. His success with multiple unit orders increased substantially with contracts in Brooklyn, New York and Boston. His experience with the multiple-unit system encouraged the growth of electric traction and his safety system for automatic train control led to another new company, Sprague Safety Control and Signal Corporation.

Between 1896 and 1900 Sprague was involved in the Commission for the Terminal Electrification of the New York Central Railroad and the Grand Central Terminal in New York City. With his constant foresight, he developed a system of automatic train control to ensure compliance with trackside signals. As a result, he formed the Sprague Safety Control and Signal Corporation to develop and build the system.

Another project at this time in liaison with William J Wilgus was the design of the Wilgus-Sprague bottom contact third rail system used by the railroads leading into Grand Central terminal. He proposed 11,000-V ac power connected from the power plant to the substations using overhead high voltage wires and then converted to 660-V dc with converters for the third-rail system or later the locomotives themselves. While ac motive power promised lower up-front and operating costs, construction expenses would be higher because of the deeper cut required by the overhead power feed. Even more importantly, there were several different, still unproven, and competing ac systems being proposed, and traffic in and out of Grand Central had to keep running during the construction phase. Considering its maturity, of the two approaches, Sprague felt dc was the only safe choice, as did Wilgus. After a further heated debate by those wanting ac, consensus was finally reached to employ 660-V dc distributed using an over-running third rail.

His interest in transportation using electricity continued and in 1901 became interested in expansion of London's Underground system. The system was operated by many independent companies one of which had pioneered the use of electric (The City & South London Railway). The Central London Railway had purchased American built 'camel-backed locomotives to pull their cars. But problems lead to the CLR choosing Sprague – Houston multiple units where each car powers its own wheels with central control from the driver's cab (the system was tried in Chicago in 1898). A control system developed by Sprague and used in Chicago was used for the extension of the London Underground electrification.

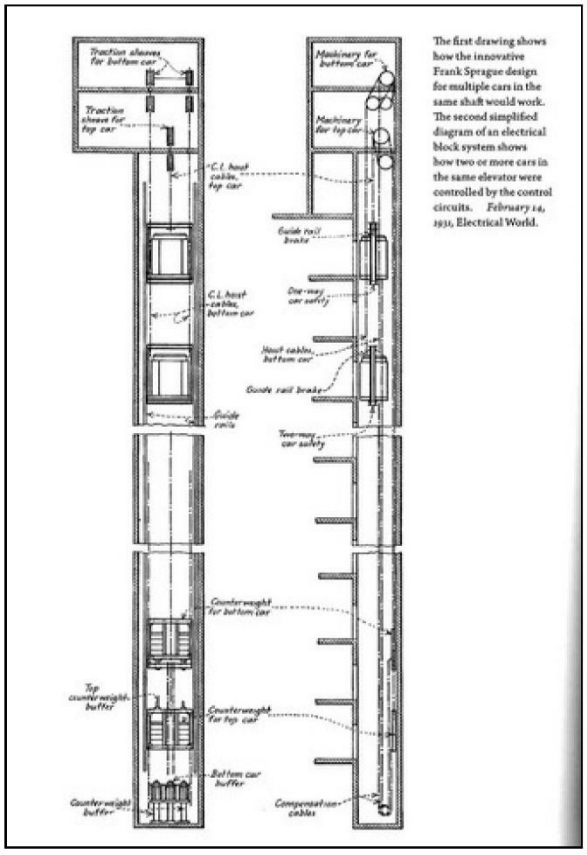

Figure 7 Sprague design for operating multiple lifts in the same shaft 1931

During World War One, Sprague served on the naval consulting board and then in 1920's he developed an express elevator, in a single shaft to conserve floor-space. He sold the Sprague's inventions and foresight have greatly contributed to electric transportation systems by rail and elevator. For inventions and devopment carryed out over 100 years ago has made possible modern light rail and rapid transit systems. The basic principles still apply nowadays albeit with rather more electronic technology.

Sprague was recognised for his many achievements in the use of electricity and engineering in many countries. He strove to make his inventions work flawlessly, improve them wherever possible and then moving onto his next project. Note 5: - Photo - Test railway car - Sprague died on 25 October 1934 and was buried at the Arlington National Cemetery.

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