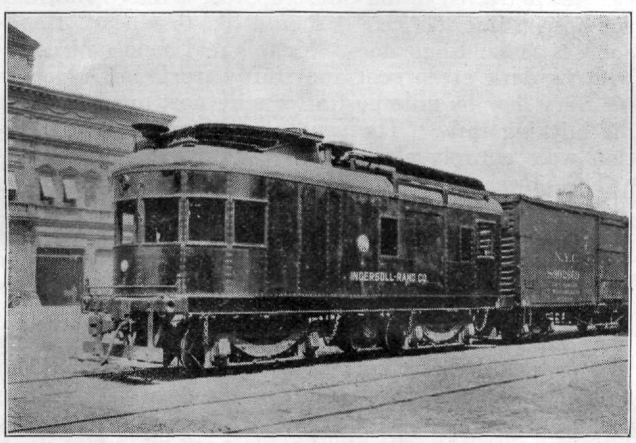
RAILROAD ELECTRO-MOTORIZING

Is the Day of the Overhead Trolley Passing?

By R. Thomas Sawyer, '23

THE oil electric locomotive is here to stay. Its high efficiency and dependability have come to challenge the high operating costs of the steam engine. This continuously increasing cost of operation is the most serious problem that faces the railroads today. The internal combustion engine is the most efficient form of prime mover at present available, as its thermal efficiency is 25% to 35% compared to 4% to 8% for the steamer. Because of its high development it is now master of the highway and air routes and is fast replacing the old steam engine on the seven seas.

The railroads are fighting more than ever the rapid increase in competition. Competition between the great railroad systems themselves is just as strong as ever. Just in the past few years several great railroad lines have been formed by consolidation—the consolidation of many short lines which has thus eliminated their competition. But the internal combustion engines on the short lines of the highways are rapidly increasing, seriously cutting into the revenue of the railroads. In the future one large system will be competing more and more with the highways, rather than a neighboring line, so all railroads will be forced to minimize operating expenses by using the most efficient dependable equipment available.



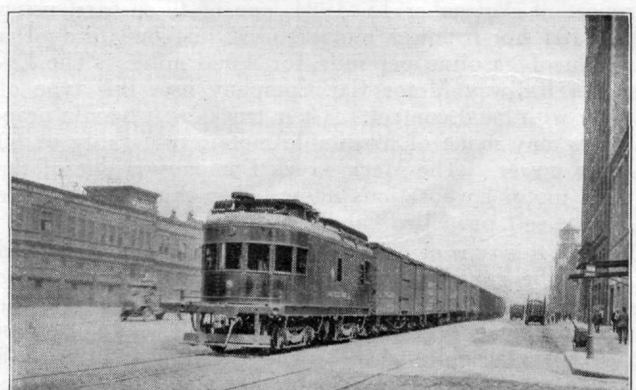
This article will discuss the various uses of the internal combustion engine and automatic electric drive most suitable for the railroad transportation of today. However, the reader must keep in mind that this is not a new field for this prime mover so universally used in all other phases of transportation. In the past twenty years over 100 gas electric self propelled cars and locomotives have been put into service and today almost all are still operating, and at a very efficient figure. During that time a great many more direct driven cars have been placed on the railroads. A great many of those have been discarded, but those that remain are of a rugged construction and were particularly built for the service rendered. Since the war, with the highly perfected internal combustion engine and automatic electric drive, a new birth has been given to this great unlimited field—Railroad Electro Motorizing.

Electric vs. Direct Drive

Rubber tires on the auto play a very important part in the life of the engine. The gears and clutch in the direct driven railroad car, with regards to driving qualities, must stand the many shocks produced by the elimination of the rubber tires. Direct drive is practical up to a certain size of car and engine, but beyond that the size of the clutch and the cost of the upkeep is far too great. Railroad and automotive engineers have found over a period of twenty years' experience that a car which requires an engine unit of much over 60 horse power is too heavy for direct drive. If the direct drive is to be used successfully, being dependable year in and year out, it must stay within the field of very light weight cars. The electric drive is used primarily for heavier cars, multiple units, and locomotives. The electric drive is free from all troubles that are inherent to the mechanical clutch. As the unit can receive no shocks from the driven wheels, thus having smooth operation and the vibration practically negligible, the upkeep of the engine is considerably less than the engine with the direct drive. The cost of maintainance of the entire unit: engine, generator, motors and accessories, has proved to be less than a complete direct drive unit with the same power. In these larger cars it is found that the over all efficiency is in favor of the electric drive, to say nothing of its automatic rapid acceleration and great flexibility of operation.

Direct Driven Cars.

"Take it," shouted the driver with a crack of the whip, as the leading stage of 20 jogged over the roads of our great Yellow Stone. That was less than ten years ago. The thousands who visit this wonderful national park each year, today tour in splendid comfortable auto busses. Over 20 years of experience has now produced a large variety of dependable light weight units to replace the old jogging steam horse and its stage coach trailer of the rails.



Of these many varieties there are three distinct types: single unit with single drive, driving one axle; single unit with multiple drive, driving more than one axle; multiple unit drive, each truck having its own engine unit. In all of these cases a very rugged construction is used, which should include standardization of parts and U. S. threads.

The first type, the single unit drive—the oldest of them all—was first started by putting an auto on rails with flanged wheels. This present form is now devoted to well built cars of the lightest construction.

The second type, the single unit multiple drive, places the engine either at one end of the car or in the center underneath. In this type, in use on cars having two four-wheel trucks, the driving shaft drives the two inside axles, or a single truck. This type produces twice the friction on the rails over the first type, but generally requires an engine of larger horse power. Cars of this type take single units up to 225 horse power. The Sykes car is one of the latest developments using such a large motor in the forward end. It will be interesting to see how these cars turn out, as this development contains such a large single unit. The J. G. Brill Car Company uses this latter type, driving one truck seperately for their standard branch line cars, using a smaller engine with its light weight car and trucks mounted on roller bearings. Practically all direct driven cars find it necessary to use roller bearings, which have proved very succussful, even on the heavy electric locomotives. The F. W. D. (four wheel drive) Truck Company is one of the many also interested in this type of a car.

The third type, multitple unit drive, brings an entirely new phase into practice, which is to insure dependability. The object of this type is to put the engine unit complete on a four wheel truck, having it drive one axle. Two of these separate units placed under a car are claimed to be the most dependable method of operation. That is, if one unit fails, the other is there to continue, and when the car is then brought into the shop this disabled unit can be replaced by another in one hour's time. These units generally use a 60 horse power motor which makes a well balanced set. Such engine trucks are of a later development and have a very promising future. On this type a direct hand control has been found most satisfactory, as the electric pneumatitc control and similar devices are complicated, and if operated improperly are liable to jam the gears. However, the Oneida Manufacturing Company uses the multiple unit drive with the pneumatic control. This company has been successful in using 70 and 104 horse power truck units, placing two under each car. In a report of November 15, 1924, one of these cars, using two 104 horse power motors, used just one-third of a gallon of gasoline per mile for 4,500 miles. The Edwards Railway Motor Car Company uses this type of drive with hand control. Their trucks will handle practically any make of a suitable motor, preferably of 60 horse power. The Mack Truck Company is one of the large motor corporations interested in this type of drive for the self propelled cars.

With this type of driving truck only one may be placed under the car, but the dependability of the multitple unit is thus lost. This has, however, been done in the past, primarily with larger motors which were not on an easily replaceable truck. The McKeen Car, with a unit of this type, is no doubt the most successful mechanical driven car of the larger size. These cars were built by the McKeen Motor Car Company. The first of these cars was built in 1905 and just before the war there were over 130 of them in operation. These cars are 70 feet long, built of all steel with a poined front, and will seat 100 people. The gasoline engine, which stands on the forward truck and swivels with it, is a 6 cylinder, 10 inch by 12 inch. It drives the front axle by means of a chain through an air operated friction clutch. Through two sets of gears it obtained a speed of 60 miles per hour.

To sum up the various types of direct driven cars, they are most generally found to be a combination of a very rugged construction and very light weight, using one or two units each developing less than 100 horse power.

Gas Electric Cars.

"Rapid-Electric." These two words go together as one thought. It was many years ago that the old puff and wheeze of the steam engine was entitrely replaced in New York City passenger service by Rapid Electric Lines. The largest steam railroad electrification in the world—Melbourne, Australia—cut the running time in half, to say nothing of the great decrease in cost of operation.

The Gas Electric of the most modern design and performance has come to Electro Motorize the vast number of branch lines throughout the United States—wherever units of 100 to 400 horse power are desired.

The Chicago Great Western Railroad and the Northern Pacific Railroad have the first two gas electric cars of the latest design. These cars were built at the St. Louis Car Company for the Electro Motive Company of Cleveland, Ohio. The writer had the pleasant opportunity of riding from St. Louis to Chicago when the first car was delivered to the Chicago Great Western Railroad for branch line service. I should like to repeat, "Handsome is as handsome does," for this real handsome coach with its dark green coat and sturdy trucks all alone in its glory flew by mile post after mile post to the tune of the clicking rails. The usual engine noises and vibration were entirely absent.

The power plant is a six cylinder of the latest type built especially for railroad service by the Winton Engine Works of Cleveland. This is directly connected to an "automatic" generator and direct connected exciter which was developed by the General Electric Company of Schenectady. The ten years before the war this company made 100 gas electric cars and locomotives, using their standard direct current self excited generator with voltage resistance grids. Most of these cars are still in operation and some have made over 1,000,000 car miles.

Two standard railroad motors on the forward truck do the driving. The six cylinder engine is of the overhead valve type and is rated at 175 horse power. It is not an adaptation of marine or automotive type of engine, but conforms to railroad practice in all its details, even to the extent that U. S. threads are used throughout. Simplicity, rigidness and accessibility are some of the outstanding features in its design.

The generator, which is also built especially for these cars, is a separate excited direct current machine delivering 110 kilowatt at 1,000 revolutions per minute. The voltage of this generator is regulated automatically by the current demand of the railway motors and it is so wound that the product of the current and the voltage is constant and equal to the engine power at any position of the throttle throughout the working range of the power plant. This type of generator eliminates the resistance grids heretofore used, which regulated the motor voltage and produced a considerable loss.

This power unit rests on one base and by extending across the car in a small compartment at the front, consumes the least amount of such valuable space. If more power is desired two units may be placed in this front compartment, making the radiator and other equipment to conform. In this case the rear truck would also have driving motors. With the double unit, three to five trailing cars may be pulled, depending upon the grades encountered, but with the single unit one and two are easily handled. The raidator is built into the front of the car with a seven horse power motor driving the cooling fan. The engineer's seat is located on the right of the cab, and on the left is the air compressor. Standard Westinghouse air brakes are used for train control. The M. C. B. couplers are also standard equipment.

The present control system has been under consideration for many years, but only recently has been brought down to this simple form. The engineer pulls the gasoline throttle back one notch, automatically starting the engine. The throttle then controls any desired amount of power with the two motors placed in series parallel, or with their fields shunted, as determined by the engineer.

Clipping along the rails at 50 miles an hour and going four miles to the gallon of gasoline in such a luxurious car is indeed a great revelation; a revelation which is making this new enterprising Electro Motive Company and the railroads heartily cooperate to further the progress of Railroad Electro Motorizing.

Oil Electric Locomotive

The world is looking for a new locomotive with a self contained power plant; a machine to replace the master of the rails of today. "Today is another day"—the very low thermal efficiency of our great steam engines must pass. Engines of 15% to 35% over all thermal efficiency are rapidly being developed by cooperation between the railroads and manufacturers to lower the steady increasing high cost of operation.

One solution is the steam turbine, geared or electric driven locomotive. Its thermal efficiency is around 15%. Experimental locomotives are now under construction and operating in this country and abroad. These include the Ljungstram Turbine Locomotive of the Swedish State Railways, one produced by the Krupp Works of Germany, and the Ramsey Turbo-Electric Condensing Locomotive built by Sir W. G. Armstrong, Whitworth and Company, of the Scotland Works in 1921. The latter locomotive is 70 feet long, has a total weight of 293,000 pounds, and its four motors are rated to deliver 275 horse power each. This turbo electric locomotive has an overall thermal efficiency twice that of our reciprocating engines, yet only one half as much as the oil electric power unit.

At this point the writer would like to quote a portion of a paper read by Direktor Christensen, at Nakskov, Denmark, with regards to the "Holeby Diesel-Electric Railroad Cars":—

"The great economic advantages which the use of Diesel motors has caused in shipping, has also made it logical to endeavor to introduce the use of Diesel motors on the railroads. During the last ten years there has been employed, as well in Denmark as in foreign countries, gasoline motor driven railroad cars for passenger traffic on branch lines with light traffic, but it has been evident to all railroad engineers that such cars only had a limited use, and did not satisfy the requirements to economy, reliability and durability, which must be made for railroad cars. The advantage of motor power can only be fully obtained by the use of the Diesel motor, which may be run with the cheap crude oil and is of equally durable and solid construction as the steam engine in the steam locomotive.

"In Denmark, the Nakskov Shipyard in conjunction with Holeby Diesel Motor Works, took this matter up in order to endeavor to find a satisfactory solution of the problem, and after several years of intensive work, they produced the very satisfactory Diesel railroad cars, which are now in service on the Maribo-Torrig Railroad. The difficulties in using the Diesel motor as prime mover for railroad cars, lies mainly in the transmission of the power from the motor to the truck wheels, because the Diesel motor, as far as possible, should constantly run at its full number of revolutions, while the revolutions of the car wheels varies during the driving. The use of gears (similar to the transmission gear in automobiles) is not practical for the great weight of the cars which have to be driven, and a satisfactory hydraulic gear has not been found yet. The 'Nakskov Shipyard' therefore, after having gone thoroughly into the matter, chose the electric transmission. . . .

"One Diesel car with a Diesel electric power unit of 100 brake horse power and a total weight of 38 tons, when running on horizontal tracks will easily make a speed of 45 kilometers (equal to about 26 miles) with a train weight of 100 tons. The fuel consumption is 40 pounds per hours at full power or at the above mentioned train weight, under one pound per kilometer. A steam locomotive would under similar conditions use about 16 pounds of coal per kilometer, which at the present is five times more expensive than the Diesel car's consumption of fuel oil.

"The same excellence which marks the Danish Diesel motor ships has now been attained in Danish built Diesel railroad cars and locomotives, and we are now in a position to take up the competition in this line, with whatever Diesel cars there may be produced in other countries."

Yes, Mr. Christian is certainly right, not only as to economy and necessity of oil electric cars and locomotives, but the fact that this company is "now in a position to take up the competition in this line in other countries." And there are several other countries throughout the world that are taking a keen interest in Diesel locomotives and cars, whether of direct, hydraulic or electric drive. Germany, the home of the Diesel engine, has long been experimenting to put this engine in railroad service. They have found the direct drive and the hydraulic drive successful but have not as yet developed the electric drive to a commercial point.

Today, in this country, after four long years of intensive research and trial practice, the Ingersoll-Rand Company of New York, in joint cooperation with the General Electric Company and the American Locomotive Company, has produced the first successful oil electric locomotive in the world. This locomotive was first put on the rails last Spring as a switching engine. Since then it has been in service and under many tests for a number of the railroads in New York City.

This may be the first oil electric locomotive, but not the last. It is understood that within another year several other companies expect to present their initiative and skill to the railroads, not only in this country, but again to all nations throughout the globe. And it shall be only human to find many other large Diesel engine companies in this country, as well as abroad, contributing their fine workmanship and energy to continue the rapid increasing progress of Railroad Electro Motorizing.

The following gives a general description of this first successful oil electric locomotive and its 300 horse power unit. This is given to convey a general idea as to what this type of locomotive consists of. All future locomotives of this type, built by this company and others, will have practically the same general principles and should only vary in minor details.

The oil engine is of the vertical, six cylinder, four cycle, single acting, variable speed type having direct fuel oil injection with moderate compression. Cylinders, cylinder heads and combustion chambers are completely water jacketed. Fuel oil injection is accomplished by means of two opposed spray nozzles in each combustion chamber to which oil is delivered under pressure by an injection pump driven from the main shaft. No compressed air is used for fuel injection. Ignition is by the heat of compression only. The lubricating is entirely enclosed and of the forced feed type. An open cooling

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water system is used on the engine with the radiators on the locomtoive roof. The water is circulated by a centrifugal pump driven from the crank shaft. To start the engine, compressed air at approximately 200 pounds pressure is admitted to each cylinder in succession through mechanically operated starting valves.

The separateley excited generator together with its exciter is specifically designed for this service and direct connected to the engine. The combined characteristics of this generator and excitor are similar to those used in the gas electric cars, as this machine produces practically a constant output. The voltage of the generator is regulated by the current demand of the traction motors so that, making due allowance for the generator losses, the product of this current and voltage is equal to the engine power.

With this generator the control of the locomotive becomes extremely simple. No rheostats are used in the power circuit, which reduces to a minimum the loss of power during acceleration. The position of the throttle lever determines the power delivered by the engine, with the motors in series or parallel, and the generator and motors transmit that power to the driving wheels, automatically adjusting the proportion of tractive effort and speed to the load on the locomotive, and automatically changing these proportions to suit the varying requirements of acceleration or grade.

The locomotive is equipped with four motors geared to the driving axle. This motor is of the series wound. totally enclosed, cummutating pole, speed frame type. The armature is carried in separate heads clamped between the motor frames and is provided with a self-aligning frictionless bearings.

There are several distinct advantages demonstrated in this type of locomotive: The thermal efficiency of the internal combustion engine is approximately 30% as compared with an efficiency of possibly 5% of a steam engine. The electric transmission protects the engine from the strains and shocks to which it is subjected with a mechanical driving transmission between engine and driving wheels. This electric transmission has the further advantage over a gear transmission that it is self-shifting. The speed ratio between the generator and the driving motors automatically adjusts itself to meet the demand of the service.

Some of the economic results of the experimental service are significant. The locomotive was in switching service from June 9th to August 23d, part of the time in 24-hour service, handling three shifts per day with only such inspection as was possible at the time of changing crews. During this time the engine used 2,400 gallons of fuel oil, equivalent to 4.15 gallons per hour of engine operation. The tonnage moved in this time was 400,000 ton miles or 166 tons miles per gallon of fuel. With a load factor of 13% the engine produced 6.3 kilowatt hours per gallon of feul. At full load it is capable of developing about 10 kilowatt hours per gallon.

This locomotive was in service in the yards of the Ingersoll-Rand Company at Phillipsburg, N. J., during the winter and spring of 1923-1924. Since that time it has been loaned to various railroads for use in switching service in competition with steam locomotives. During June and July, 1924, it was in service on the West Side lines of the New York Central Railroad hauling freight trains between 33d Street yards and St. John's Park. After that it was put in service in the Mott Haven and Winchester Yards. The Baltimore & Ohio Railroad used it first in their freight yards at West 26th Street and later on the Staten Island freight yards. It was then used in the Bronx Terminal yards of the Central Railroad of New Jersey and in the Stanford and New Haven yards of the New York, New Haven & Hartford Railroad.

The Future

Robert Fulton built the first commercial steam boat and put it into regular service on the Hudson in the year 1803. That was a side wheeler—and still today the boats that ply up the Hudson are side wheelers, large modern ships built for that particular service. Then the mighty liners came with their reciprocating engines, only to be replaced by the steam turbine and oil engine.

Today—a century and twenty years later—on the banks of this same historic river operated the first successful oil electric locomotive. There is no question as to its necessity. Its great economy and dependability is producing a record which all railroads are watching with keen interest. And the future of this locomotive is guaranteed by the exceedingly high thermal efficiency of the internal combustion engine which is now a vital necessity to all other methods of transportation. This past twenty years of research and commercial experience has not only developed this oil electric locomotive and highly perfected the gas electric car, but has formed a firm foundation upon which to build an unlimited future.