As will be observed, the heating surface is entirely in the tubes, the upper and lower sections being protected by the brick-work. For burning sawdust, wet tanbark, the furnace may be fed through the hopper. The piping, both steam and water, should be double, that is on both sides, and connected at the inlet and outlet. The feed water should enter at the water surface of the boiler next to the chimney. Each boiler should be tested in shop to twice the working pressure.

It is fast becoming recognized that steam boilers intended for service in costly buildings and manufactories should be of the safety type. If from neglect or other causes the water supply be insufficient in the ordinary type of boiler, disastrous explosion may follow, for the reason, as many people believe, that a very large proportion of the heating surface becomes exposed and weakened by low water. If from neglect of interior cleaning of the tubes, or from insufficient water supply, the tubes of the boiler herein presented should become heated, they would split in the direction of their length, and immediately extinguish the fire by discharging water or steam; there would be no further damage for the reason that the tube, although split, still retains its former holding power.

THE DESSAU STREET RAILWAY.*

The aim of the paper is to show the characteristic features of gas traction, to describe the recent experiences at Dessau, and to discuss the results obtained in that city. The three important elements of operating a gas road are the storage of gas, the motor, and the mechanical apparatus. That which presents the principal interest to the public is the storage of the gas and the imaginary risk of an explosion of it in the car. In the last 25 years more than 60,000 railroad cars in different countries have carried gas under high pressure to operate the Pintsch illuminating system, without ever having produced a single explosion or alarmed the passengers, the great pressure itself evidently preventing the possibility of the entrance of air into the cylinders to form an explosive mixture, and at the same time facilitating the discovery of any leaks. The use of the gas itself is even less dangerous in a car motor where the combustion takes place in a cylinder constructed to resist explosive forces, than it is for the illumination where the flame is protected only by a glass globe. The explosions of gas in the cylinder of the motor cannot produce a pressure above a certain limit for which maximum the cylinder is designed. The sole combustion in the Otto engine produces a pressure increasing not much more rapidly than that in the high-pressure steam cylinder, and the maximum gas pressure produced of 20 to 30 atmospheres is not comparable with the pressure of over 100 atmospheres developed by carbonic acid, and safely confined in steel cylinders. Railroads transport cylinders charged to 200 atmospheres, which is about ten times as high a pressure as is required for street-car service, therefore there need be no question or alarm concerning the safety of the gas stored.

In considering whether the cost and maintenance of gas motors is too high for the operation of street cars, it is admitted that the first six months' experience at Dessau are not sufficient to solve the question and indirect deductions must be drawn from the operation of older machinery. The careful investigation made by the company that I represent has produced a very favorable reply. Repairs were limited in most cases to replacing segments of the piston after continuous work or redressing the slide bar in the older machines. The expenses of repairs for the last 8½ years upon gas machine engines of 10, 30, 60 and 120 horse-power at the small central electric station at Dessau have only been $\frac{1}{100}$ of 1 per cent. per year of the initial cost. In reply to an inquiry concerning the gas motors of 50 horse-power at the electric-light station at Prague, the astonishing reply was made that the expense for eight years had been nothing. This probably means that the necessary repairs had been accomplished by their ordinary workmen without extra expenses. On some other gas engines the cost of repairs for seven to twelve years had been in different cases about $40 for one 12 horse-power machine, about $220 for 20 eight horse-power machines, and about $18 for one 12 horse-power machine. Therefore it is fair to conclude that the maintenance of gas motors is as cheap as of high-grade steam engines. The gas motor is not more sensitive to dust than is the steam engine, while in the Luhrig cars the motor is entirely protected from the dust. The cars in the Dresden system have crossed for many a year 26 times a day five lines of car tracks, so that each axle has received daily 260 violent shocks, but no special repairs have yet been required on the motor.

It has been feared that the transmitting and reversing gear would be very complicated, but in reality it is very simple. These gas motors are criticised for producing a disagreeable odor and vibrations noticeable when the car is at rest, but none of these was observed by the numerous visitors at Dessau, although their attention was especially directed to it. This was due to a careful regulation of the admission of gas and the use of automatic oilers. The importance of compressed coal gas is indicated by the formation during the last year at Havre of a company for the contract of boats between Havre, Rouen and Paris, with motors having coal gas compressed to 100 atmospheres in iron cylinders. The first boat of this kind has a 40 horse-power motor and carried 145 tons 72 kilometers without refilling the gas reservoirs. The work required to compress the gas does not increase proportionately to the pressure, but is relatively much less for high pressures. Thus to raise a pressure of 10 atmospheres to 100 atmospheres is only necessary to increase the power 2½ times. It is hoped that the distances run by gas cars at one charging of receivers may become much greater in the future so that gas motors may be employed on small local street cars, but there is no immediate probability that acetylene will be used in the motors, for although it has about 15 times the illuminating power of ordinary gas, it has only 2½ times its value for heating. The operation of the gas cars is maintained with regularity throughout the severe winter. If one car becomes stalled it is easily pushed by the following one.

Regarding the financial side of the question, the figures secured during the six worst months of the year are not very valuable, and the expenses for the commencement of operations are not a fair indication for the future, but the consumption of gas will be constant, and this expense has been determined not only for a half a year, but even for a single day, and the ease of establishing this principal factor of expenses is a special advantage of the new system. Two meters placed at the compressing station give the quantity of gas used by the compressor and

* Abstract of a paper by M. von Oechelhaeuser, Director of the German Continental Gas Company, presented to the Association of German Gas and Water Engineers in 1895.