under which the engines have to work. A tramway engine must be able to draw its load up steep gradients, demanding perhaps seven or eight times the power required on a level, and it must have the necessary adhesion without being too heavy for the permanent way. It must be capable of traversing sharp curves, of going backwards or forwards with safety, and of stopping and starting quickly. For the safety and convenience of the public the Board of Trade require that tramway engines shall have brakes to each wheel, to be applied by hand and by steam, a governor so arranged as to shut off the steam and apply the brakes when the engine exceeds the speed of 10 miles an hour or other stated speed, an indicator to show the speed, a whistle or bell to be sounded as a warning, and a fender to push aside obstructions; the engine must be free from noise produced by blast, and from clatter of machinery such as to constitute a reasonable ground of complaint ; and the machinery and fire must be concealed from view ; no smoke or steam must be emitted so as to constitute any reasonable ground of complaint to passengers or the public.

The first attempt to use steam on a modern tramway was with Grantham’s combined engine and car. It was about 25 feet long, having a vertical boiler in a central compartment, with the steam cylinders below, driving one pair of wheels 2 feet 6 inches in diameter. It carried 20 passengers inside and 24 outside, weighing 6½ tons empty and 12 tons when fully loaded. In a later car the boiler and machinery were at one end, and the body of the car was carried on a bogie frame. In a combined engine and car the λveight of the car and passengers is utilized for adhesion of the driving wheels, and this is conveniently effected in Rowan’s car, in which there are two four-wheel bogies, the leading one carrying the engine and boiler, and half the body of the car and passengers. The engine can be detached from the car for repair and another engine can be substituted in a few minutes. Economy of rolling stock, and the advantage of being able to use cars intended for horses, are in favour of independent engines. They are usually in general construction similar to locomotives, but are enclosed so as to resemble in outward appearance a short tramcar. The cylinders are 6 to 9 inches in diameter, with a stroke of 10 to 12 inches. The wheels are coupled, 2 to 3 feet in diameter, and the engines weigh 4 to 6 tons with fuel and water. The governor to shut off steam and apply the brakes when any determined speed is attained is actuated either by the engine wheels or by an independent wheel to prevent the possibility of the brakes being put on when the driving-wheels slip. An effectual way of rendering the exhaust steam invisible is to condense it by passing it through water in a tank, or through a shower of water let off at each blast, but when the water gets hot it must be changed, and in streets it is difficult to get rid of the hot water. Several methods of superheating by passing the exhaust steam through the fire have been adopted, but they are all attended with an increased consumption of fuel, which in cold damp weather is considerable. It is now preferred to pass the steam into tubes exposed to the air on the top of the engine car, from which the condensed water is returned to the feed-tank, to be again pumped into the boiler at a high temperature. Any steam remaining uncondensed passes into the smoke-box. Com­pound cylinders have been applied to tramway engines, giving a greater range of power, economizing fuel, and rendering the exhaust steam easier to deal with. The extra complication of a compound engine is, however, a drawback.

The cost of steam traction with engines of ordinary size is gene­rally 3d. to 4d. per mile run by the engine, and more on lines with steep gradients. To this must be added for depreciation 10 per cent., or, according to some authorities, 15 per cent. on the original cost of the engines, making altogether 4d. to 6d. per mile run on a tramway with average gradients.

Fireless engines were first tried in New Orleans, and have been in successful use on tramways in France for some years. The motive power is obtained from water heated under pressure to a very high temperature in stationary boilers and carried in a reservoir, where it gives off steam as the pressure and temperature are reduced. Two tons of water heated to give a steam-pressure of 250 lb to the square inch serves for a run of 8 or 10 miles, leaving more than 9/10 of the water and a pressure of 20 to 25 lb above the atmosphere on returning to the boiler. Large boiler-power is required to reheat the engine reservoirs quickly, and this cannot be afforded for only a few engines, but, when worked on a sufficient scale, the fireless engines are claimed to be economical, the economy resulting from the generation of the steam in large stationary boilers.

Compressed air as a motive power offers the advantage of having neither steam nor the products of combustion to be got rid of. In Scott Moncrieff's engine, which was tried on the Vale of Clyde tramways in 1876, air was compressed to 310 lb on the square inch, and expanded in the cylinders from a uniform working pressure to that of the atmosphere. There is a considerable loss of heat during the expansion of the air which is attended with a serious loss of pressure, and in Mékarski’s system, which has been in use for the propulsion of tramcars at Nantes for seven years, the loss of pres­sure is considerably lessened by heating the air during expansion. The air, at a pressure of 426 lb per square inch, is stored in cylindrical reservoirs beneath the car, and before use is passed through a vessel three quarters full of water heated to 300° F., by which it is heated and mixed with steam. The heat of the latter is absorbed by the air during its expansion, first to a working pressure which can be regulated by the driver, and then to atmospheric pressure in the cylinders. At Nantes the average cost for three years for propel­ling a car holding 34 persons was about 6d. per mile.

In San Francisco a main charged with air at a pressure of about 120 lb per square inch has been laid along the tram route, from which reservoirs on the cars are charged by means of standpipes and flexible connexions at convenient points, the operation taking a very short time. The inventor claims to utilize 30 per cent. of the power applied to the compressor.

Street tramways worked by means of a wire rope have been in successful operation in San Francisco since 1873. There are now upwards of 24 miles of double line in San Francisco, and 10 miles in Chicago, and the system is being adopted in other American and colonial cities. It has also been in operation in England at Highgate Hill for several years, and is about to be adopted in other localities. The motive power is trans­mitted from a stationary engine by a rope of steel wire running always in one direction up one track and down the other, in a tube midway between the rails, on pulleys which are arranged so as to suit curves and changes of gradient as well as straight and level lines. Over the rope is a slot ¾ inch wide, in which travels a flat arm of steel connecting the dummy car with the gripper which grasps the cable. The flat arm is in three pieces, the two outer ones constituting a frame which carries the lower jaw of the gripper, with grooved rollers at each end of it, over which the cable runs when the gripper is not in action. The upper jaw is carried by the middle piece, which slides within the outer frame, and can be de­pressed by a lever or screw, pressing the cable first on the rollers, and then on the lower jaw until it is firmly held. The speed of the cable, which is gene­rally 6 to 8 miles an hour, is thus imparted to the car gradually and without jerk. The arrangements for pass­ing the pulleys, for changing the dummy and cars from one line to the other at the end of the road, for keeping the cable uniformly taut, and for crossings and junctions with other lines are of considerable ingen­uity. When the cars are cast off from the cable they must be stopped by hand brakes, which on steep gradients especially must be of great power.

The system has advantages on double lines with few and easy curves when the gradients are long and steep, and it can be employed on gradients too steep for steam traction. On level lines it is doubtful if it could compete in economy with steam, or even with horse traction, unless with a very frequent service of cars, though then it presents the advantages of being comparatively quiet, and free from smoke and steam, and of admitting a frequent service of cars with little extra cost. On the cable roads of San Francisco it has been found that, of the average daily power em­ployed, 68 per cent. is expended in moving the cables, &c., 28 per cent. for the cars, and 4 per cent. for passengers. It is considered that it is practicable to utilize in moving cars and passengers as much as 50 per cent. of the power, provided the cars are fully loaded and run at short intervals.

Electricity has been applied as a motive power on a tramway about 2 miles long at Blackpool. The current is conveyed by two copper conductors in a central channel beneath the roadway, and is communicated to the motors in the car by a collector running