first. The conductors are out of reach, they can easily be doubly or trebly insulated, and with their insulators are open to inspection. The poles and wiring can be erected without closing or obstructing the street. The supply of power is not interfered with by heavy rain, snow or other climatic causes. Duplicate conductors are used, and repairs can be rapidly executed. The only objection is that of unsightliness, which, however, can be greatly reduced by good design.

The cost of establishing tramways to be worked on the various systems of traction mentioned above has varied considerably. The locality and the amount of street widening have considerable influence on the total. Horse tramways in the larger cities cost in the past about £15,000@@1 per track mile complete with horses, cars, &c., tramways worked by steam power about £18,0002 per track mile including locomotives and cars. The Edinburgh Corporation cable tramways cost £23,316@@3 to establish complete with power- house, cars, &c. Of this figure, the cost of the permanent way construction amounted to £14,431.3 The construction and equipment of the South London conduit tramways cost £25,1063 per mile of single line; the permanent way, its electrical equipment and the distributing cables cost £15,8953 per track mile. More recent estimates appear to show that the average cost in London will be between £26,000 and £30,000 per, track mile. In Glasgow the total cost of constructing and equipping the electric tramways on the overhead system, including the provision of a power station, cost £19,787@@\* per track mile, and at Leeds £13,206. At Manchester, where current is provided by the lighting station, the complete cost works out at £12,498.@@® The cost of the permanent way, cables and electrical equipment per track mile vanes from £6575 at Man- chester to £9959 at Glasgow. The cost of laying down a surface contact electric tramway is about slightly more than that of con­structing and equipping a track with overhead conductors. The cost of the permanent way and its electrical equipment together with the cables at Wolverhampton on the Lorain surface contact principle amounted to £8601 per track mile.

The working expenses of the various systems of traction are largely affected by the age of the tramway, the locality, and, in the case of electric lines, by the cost at which power is obtained. In Birmingham in 1890-18916 horse traction cost 9∙79d. per car mile, steam traction 10∙99d. per mile, cable traction 6∙33d. and electric accumulator traction 9∙9od. per car mile. Modern electric trolley lines generating their own current work at from 5d. to 6d. per car mile. Where current is purchased the costs vary from 6d. to 7½d. per car mile. The working costs of the London County Council conduit tramways worked on purchased current amounted to 8∙02d. per car mile in the year 1905-1906.

*Tramway Cars.*—The modern tramway car is made up of two distinct parts, the body and the truck. The present type of double ended car with a platform at each end was first used on the American street railways about 1860. The car body was supported directly on axle-boxes through helical steel or rubber springs.

When the early pioneers were experimenting in the United States with electric traction they attached the motor to the car body. This proved unsatisfactory, and resulted in the develop­ment of the modern truck. The truck may be described as a carriage or frame supported on the axle-boxes by springs and supporting by another set of springs the car body. The truck carries the motors and in itself resists all the strains of the driving mechanism.

Modem car bodies are mounted either on a single four-wheeled truck, with a fixed or rigid wheel-base, or on two four-wheeled bogies or swivelling trucks. Four-wheeled radial trucks have been tried on several tramways, but they have not proved satis­factory. The wheel-base of the fixed or rigid truck usually varies from 6 to 7 ft. The length of the wheel-base should be determined by the radius of the sharpest curve. To obtain steady running it should be made as long as possible. Two motors are generally fitted on a car.

Of the bogie or swivelling trucks the greater number now in use are of the “ maximum traction ” type. This truck is used to obtain the greatest tractive effect from two motors when fitted to a car supported on eight wheels. Each bogie is a small four-wheeled

truck in itself. It has one pair of its wheels driven by the single motor and of the standard size—about 30 in.—while the guiding or “ pony ” wheels are of small diameter. The weight of the car body is supported eccentrically on the truck, so that about 70 % to 80% is available for adhesion under the driving-wheels. While this form of truck has many merits, it also has many disadvantages. The small wheels easily leave the rails, while the adhesion of the driving-wheels compared with a four-wheeled car is considerably reduced. Quick acceleration is difficult, and on a greasy rail much energy is lost in slipping. The use of equal-wheeled bogies with a motor on every axle gets over the difficulty of the loss of adhesion but at a greatly increased cost. The current consumption is increased, the first cost is greater, and there are four instead of two motors to be maintained. Steel-tired wheels have largely replaced the cast- iron chilled wheel for many years used on tramcars.

While the various forms of trucks are common both to British and American practice, car body construction differs in many points. The single-deck car is universal outside the United Kingdom, where, although many single-deck cars are worked, the greater number are of the double-deck type. It is claimed that with small single-deck cars a quicker service can be maintained, as they are easier to load and unload and generally handier. On the other hand, the double-deck car seats more than double the number of passen- gers, requires the same number of men to work it, and takes but little more power to drive it. Experience has proved that the 58-passenger —28 inside and 30 outside—double-deck car mounted on a four- wheeled truck is the type of rolling stock most suitable for British conditions. For heavy rush traffic or long distance travel the larger bogie cars are convenient. They are, however, slow to start and stop, and a 72-passenger car is too much for one conductor to work efficiently. Another difference is due to the width of the cars. In the United States car bodies vary from 8 ft. to 9 ft. 6 in. in width. In Great Britain the width is limited by the Tramways Act of 1870 to 11 in. beyond the outer edge of the wheels, which, on the standard gauge, allows the maximum width to be 6 ft. 10 in. This limit has governed the arrangement of the seating in the cars. Inside, the ordinary side seat is almost invariably adopted. Cross seats have been used, but they leave a very narrow gangway—a great disadvantage at times of overcrowding. On the top deck, where the available width is greater and standing is never permitted, cross seats are universally fitted.

On the old horse cars a straight type of stairway was used. The reserved stairway, brought in about 1902, gave greater protection from accident and increased the seating accommodation on the top deck. It had, however, two great disadvantages. The stairway shut out the motorman’s view on the left-hand side, and the stream of passengers descending met the stream of passengers leaving the inside of the car, causing delay. The reversed type of stairway has now been abandoned and the straight type, well protected by railings, is usually fitted.

In addition to the ordinary single-deck and double-deck types of cars which are in general use many other designs are to be found. Single-deck open cars of the “ toast-rack ” type with transverse seats are popular on many holiday lines. They have the advantage of being quickly filled and emptied. Centre vestibule cars are now seldom seen. It is inconvenient not to have the conductor at the back of the car where he can look out for passengers, and, if necessary, “ nurse ” the trolley. There is also danger of a passenger being struck by the axle-boxes of the rear bogie truck when leaving the car. The Californian type of car body, with the central part closed in and one or two double-sided transverse seats at each end, has been used on routes where low bridges do not allow of the use of double-deck cars. The carrying capacity of this type in wet weather when the exposed seats cannot be used is small. A demi or one-man car has been worked in some towns. It saves the wages of one man, but the average speed of the service is reduced. Top deck covers have in recent years been largely fitted. Their use practically doubles the covered seating capacity of the car and provides accommodation for smokers, a difficult matter on a single-deck car.

In Great Britain the board of trade requires all cars to be fitted with an efficient form of lifeguard. The gate and tray pattern, in which anything striking the vertical gate drops the tray, is that principally employed. In addition to the ordinary hand-brake which operates shoes on all the wheels, and the electric reverse switch, a large number of cars are fitted with some form of electric brake (see Traction).

*Legislative Conditions in Great Britain.—*The first tramways constructed in Great Britain were promoted by private enter­prise under powers conferred by private acts of parliament. Considerable opposition was offered to pioneer schemes, but after a few private acts had been passed, parliament, in 1870, passed a general act providing for the laying of rails upon roads, and specify­ing the procedure for tramway promotion and the main relations between tramway undertakers and local authorities. The Tramways Act 1870, which is still in force, enabled promoters to apply to the board of trade for a provisional order which, when confirmed by parliament, possesses all the force of an act of

@@@1 and 2 See *Tramways: Their Construction and Working,* by D. K. Clarke.

*@@@\* Proc. Inst. Ciυ. Eng.* 156, p. 179.

@@@4 Tramway Accounts, year ended March 31, 1906.

5 Ibid., year ended March 31, 1905.

@@@β See *Tramways: Their Construction and Working,* by D. K. Clarke.