there are not those costs of maintenance which become unavoidable where the sleepers are fixed by means of bolts, clamps, or other adjuncts, only too liable to be lost. Moreover, tracks which are not capable of separation are lighter and therefore more portable than those in which the sleepers can be detached.

With regard to sleepers, a distinction must be drawn between those which project beyond the rails, and those which do not so project. The author has adopted the latter system, because it offers sufficient strength, while the lines are lighter and less cumbersome.

Where at first he used flat iron sleepers, he now fits his line with dished steel sleepers, in accordance with Figs. 1 and 2, Page 228. This sleeper presents very great stiffness, at the same time preserving its lightness ; and the feature which specially distinguishes this railway from others of the same class is not only its extreme strength but above all its solidity, which results from its bearing equally upon the ground by means of the rail-base and the sleepers.

In special case, the author provides also railroads with projecting sleepers, either of flat steel beaten out and rounded, or of channel of iron; but the sleeper and the rail are always inseparable, so as to avoid lessening the strength, and also to facilitate the laying of the line. If the ground is too soft, the railway is supported by bowl sleepers of dished steel, Figs. 3 and 4, Page 228, especially at the curves ; but the necessity for using these is but seldom experienced. The sleepers are riveted cold. The rivets are of soft steel, and the pressure with which this riveting is effected is so heavy that the sleepers cannot be separated from the rails, even after cutting off both heads of the rivets, except by heavy blows of the hammer, the rivets being driven so thoroughly into the holes in the rails and sleepers as to fill them up completely.

The jointing of the rails is exceedin ly simple. The rail to the right hand, Fig. 5, Page 228, is furnished with two fish-plates : that to the left has a small steel plate riveted underneath the rail and projecting 1¼ inch beyond it. It is only necessary to lay the lengths end to end, making the rail which is furnished with the small plate come in between the two fish-plates, and the junction can at once be effected by fish-bolts. A single fish bolt, passing through the holes in the fish-plates, and through an oval in the rail-end, is sufficient for the purpose.

With this description of railway it does not matter whether the curves are to the right or to the left. The pair of rails are curved to a suitable radius, Fig. 6, Page 228, and only need turning end for end to form a curve in either direction. The rails, Fig. 14, Page 229, weigh 9 lbs. per yard, 14 lbs., 19 lbs., and 24 lbs. per yard ; and are very similar to the rails used on the main railways of France, except that their base has a greater width in proportion. As to the strength of the rails it is much greater in proportion to the load then would at first sight be thought : all narrow-gauge railways being formed on the principal of distributing the load over a large number of axles, and so reducing the amount on each wheel. For instance, the 9 lbs.rail used for the portable railway bears easily a weight of half a ton for each pair of wheels.

The distance apart between the rails differs according to the purpose for which they are intended. The most usual gaugs are 16, 20, and 24 inches. The line of 16 ins. gauge, with 9 lbs. rails, although extremely light, is used very successfully in farming, and in the interior of workshops.

A length of 16 ft. 5 ins. of 16 ins. gauge, with 9 lbs. steel rails and sleepers &c., weighs scarcely more than 1 cwt., and may therefore be readily carried by a man placing himself in the middle and taking a rail in each hand.

The members of the Institution who recently visited the new Port of Antwerp well recollect seeing there the portable railway which Messrs. Couvreux and Hersent had in use ; and as the works at the Port of Aniwerp gave rise to the idea of this paper, it will be well to begin with a description of this style of contractors' plant.

The earth in such works may be shifted by hand, horse-power or locomotive. For small works the railway of 16 ins. gauge, with the 9 lbs. rails, is commonly used, and the trucks carry double-equilibrium tipping-boxes, containing 9 to 11 cub. ft. These wagons, of smaller size than those shown in Figs. 17 and 18, Page 232, but of similar construction, having tipping-boxes without any mechanical appliances, are very serviceable ; the box, having neither door nor hinge, is not liable to need repairs, and it keeps perfectly in equilibrium upon the worst roads. To tip it up to the right or left, as shown dotted in Fig. 17, it must simply be pushed from the opposite side, and the contents are at once emptied clean out. In order that the bodies of the wagons may not touch at the top, when several are coupled together, each end of the wagon is furnished with a buffer, composed of a flat iron bar cranked, and provided with a hanging hook.

Plant of this description is now being used in an important English undertaking at the port of Newhaven, where it is employed not only on the earthworks, but also for transporting the concrete manufactured with Mr. Carey's special concrete machine.

These little wagons, of from 9 to 11 cub. ft. capacity run along with the greatest ease ; and a lad could propel one of them with its load for 300 yards at a cost of 3*d*. per cubic yard. In earthworks the saving over the wheelbarrow is 80 per cent. ; for the costs of wagons propelled by hand comes to 1*d*. per cubic yard carried 100 yards, while to go this distance with a barrow costs 5*d*. A horse draws without difficulty, walking by the side of the line, a train of from 8 to 10 trucks on the level, or 5 on an incline of 7 per cent. (1 in 14).

One mile of this railway, of 16 ins. gauge and 9 lbs. steel rails, with 16 wagons, each having double-equilibrium tipping-box containing 11 cubic feet, and all accessories, represents a weight of 20 tons,—a very light weight, if it is considered that all the materials are entirely of metal. Its net costs price per mile is £450, the wagons included.

Large contracts for earthwork with horse haulage are carried on to the greatest advantage with the railway of 20 ins. gauge and 14 lbs. rails. The length of 16 ft. 5 ins. of this railway weighs 170 lbs. ; and so on can be carried easily by two men, one at each end. The wagons most in use for these works are those with double-equilibrium tipping-boxes, holding 18 cub. ft., Figs. 17 and 18, Page 232. These are now being employed in one of the greatest undertakings of the present time—namely, the cutting of the Pannama Canal, where there are in use upwards of 2700 such wagons and more than 35 miles of track.

A mile of this railway of 20 ins. gauge with 14 lbs. rails, together with 16 wagons of 18 cubic feet capacity, with appurtenances, costs about £660, and represents a total weight of 33 tons.

This description of plant is used for all contracts exceeding 20,000 cubic yards.

A very curious and interesting use of the narrow-gauge line, and the wagons with double-equilibrium tipping-box, was made by the Société des Chemins de fer Sous-Marins on the proposed tunnel between France and England. Fig. 19, Page 233, represents a section of the tunnel, with two lines of rails, on one of which is a train of wagons, and on the other an inspection carriage with two seats. The line used is that of 16 ins. gauge, with 9 lbs. rails.

The first heading of the tunnel, which was driven by means of a special machine by Colonel Beaumont, had a diameter of only 2. 13 m. (7 ft.) ; the tipping-boxes have therefore a breadth of only 2 feet, and contain 7½ cubic feet. The boxes are perfectly balanced, and are most easily emptied. The wagons run on two lines, the one being for the loaded trains, and the other for the empty trains.

The engineers and inspectors, in the discharge of their duties, make use of the Lilliputian carriages shown in Figs. 19 and 20, Page 233. The feet of the travellers go between the wheels, and are nearly on a level with the rails : nevertheless they are tolerable comfortable. They are certainly the smallest carriages for passengers that have ever been built ; and the builder prophesies that these will be the first to enter England through the Channel Tunnel.

One of the most important use to which a narrow-gauge line can be put is that of a military railway. The Dutch, Russian, and French governments have tried it for the transport of provisions, of war material, and of the wounded, in their recent campaigns. In Sumatra, in Turkestan, and in Tunis, these military railroads have excited much interest, and have so fully established their value that a short description will here suffice.

The campaign of the Russians against the Turcomans presented two great difficulties, in the crossing of the districts where water was extremely scarce or failed entirely, and in the victualling of the expeditionary forces. The latter object was compeletely effected by means of 67 miles of railway, or 20 ins. gauge and 14 lbs. steel rails, with 500 carriages for food, water, and passengers. The rails being laid simply on the sand, small locomotives could not be used, and had to be replaced by Kirghiz horses, which drew with ease from 16 cwts. to one ton for 25 miles per day.