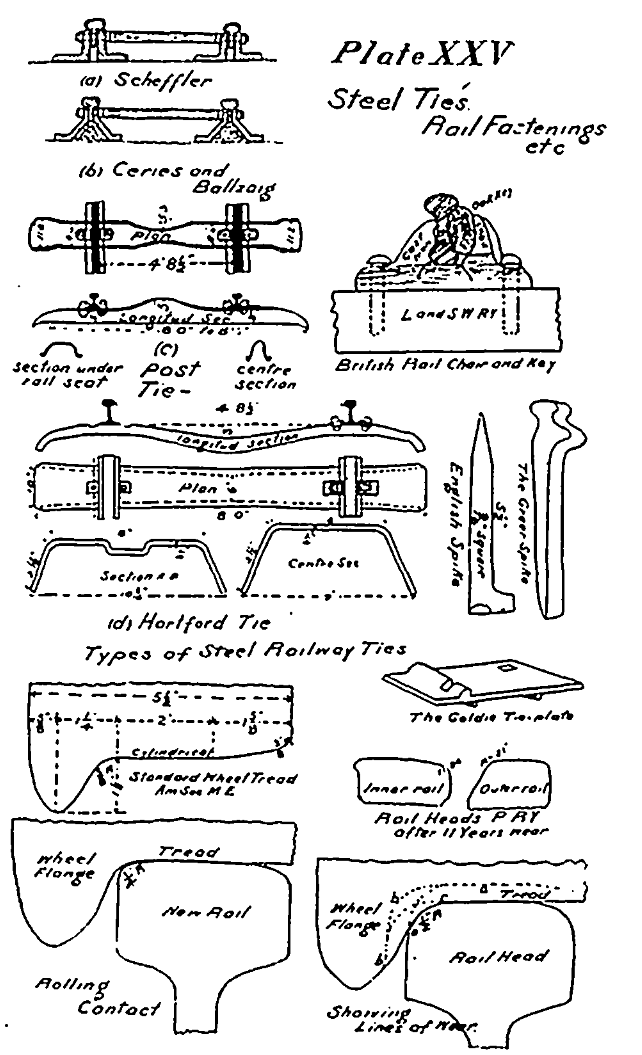
the spike, but none have been very successful. Metal tie plates such as the one shown on Plate XXV. are now used on heavy traffic roads, sometimes only on curves, and latterly under all the track. These spread the load over a larger surface, and are a great improvement, as they enable a cheaper tie and a deeper rail, relatively to its width of base, to be used. When railway managers in America see the wisdom of adopting wood screws or fang bolts, as in England, for holding the rails in place, a much superior track will be obtained even at a small increase of first cost.



There are several ways of increasing the ordinary life, in track, of a wooden tie, for a tie rots by the solidification of fermented sap, assisted by heat or dampness :

(1) By thorough drainage of the ballast.

(2) By having as little sap as possible in the tie by felling the tree in winter, and subsequent natural, steam, or other form of seasoning.

(3) By charring the surface.

(4) By impregnating the tie with an antiseptic to prevent fermentation.

Such chemicals as sublimate of mercury, sulphate of copper, chloride of zinc, and creosote or oil of tar, serve the purpose more or less successfully, especially the last two, and the last one most particularly. Creosoting is done in a closed receiver, after the tie has been air seasoned two or three months, and trimmed of its sapwood, by exhausting the air to suck out the sap from the pores of the wood. Creosote at 120° F. is then forced in at 10 atmos. pressure, and after one hour the ties are taken out ready for use; soft woods, which are the only ones usually treated, absorb 7 to 9 lbs. per cubic foot, and the cost of treatment has been reduced from 21 cents in 1879 to 10 cents per tie at the present time. The increase in the life of ties in track is greatest amongst soft woods according to the following table :

Timber.	Duration in track. Untreated.	Creosoted.
Oak	13	19
Pine	7	15
Fir (Spruce)	5	9
Beech	3	16

Creosoted ties will not resist the cutting of rails more, nor are they stronger than untreated ones, but, especial y in thickly settled countries, discarded ones will be more valuable as fence posts or fuel, being worth from $\frac{1}{8}$ to $\frac{1}{10}$ of first cost.

Creosoting does not assist ties to hold spikes, and in this respect wooden ties are deficient. Spikes with hard-wood ties on roads of moderate traffic are one thing, with soft-wood ties or with any tie on heavy traffic roads are another. As they are continually being pulled loose by the action of passing trains, and have to be redriven, in the future, with heavier traffic, rails and engines, something must be done to remedy this weakness of American track, the solution of which will lie along two lines, either metal ties and appropriate fastenings, or oak or other durable ties along with tie plates, and fang bolts or wood screws as fastenings—either method will allow deeper rails to be used, or ties spaced farther apart.

Metal Ties.—Three types of metal rail-supports are used :

(1) Longitudinal flanged sleepers giving a continuous support to the rail, and held to gauge transversely by rods; sections of these are shown on Plate XXV. (a) and (b); they have never come into anything like general use.

(2) A succession of cast-iron inverted pots, filled inside with ballast and connected transversely by rods, as in class (1); this method has been used in regions of brackish soils where cast iron rusts less than steel, and can be made heavier, as it is a cheaper material; this method is also only in limited use.

(3) Metal cross ties of inverted trough sections are steadily increasing in favor and are likely to obtain, in the future, general adoption.

The tendency of metal cross-ties is to decrease maintenance charges year by year, while with wooden ones, especially on curves, the reverse is the case. Of these the Post tie seems to be the favorite in Europe; on the Netherlands railway, maintenance with metal ties was about one-half of what it was with oak ones, with thirty trains per day and engines of fifty tons, and no ties reported broken. A sketch of this tie is given on Plate XXV. (c); it is of mild steel, weighing 110 to 120 lbs. each, and costing a few years ago $22 to $26 per short ton, with two year guarantee. It is closed at the ends, narrow and deep at the middle, with thickness varying, being greatest at rail seats; the bottom edges are in the form of ribs $\frac{3}{4}$ inch thick, projecting $\frac{1}{2}$ inch. The general thickness is $\frac{1}{4}$ to $\frac{1}{2}$ inch. The narrowing in and deepening at middle gives transverse strength, and prevents the track from creeping longitudinally, or forming a hog back at the centre. The rails are fastened by bolts with T heads and eccentric necks. These bolts pass through the tie from underneath, and into a crab washer which bears on the rail flange and tie; a Verona nut-lock and a nut complete the fastening, and an oblong hole through the ties allows adjustment on curves. This tie presents economy of material and maintenance and general efficiency. It has been in long, extensive use in Belgium, Holland and France, and is probably the best metal tie yet devised for flanged rails. In the United States the Hartford tie has been used with