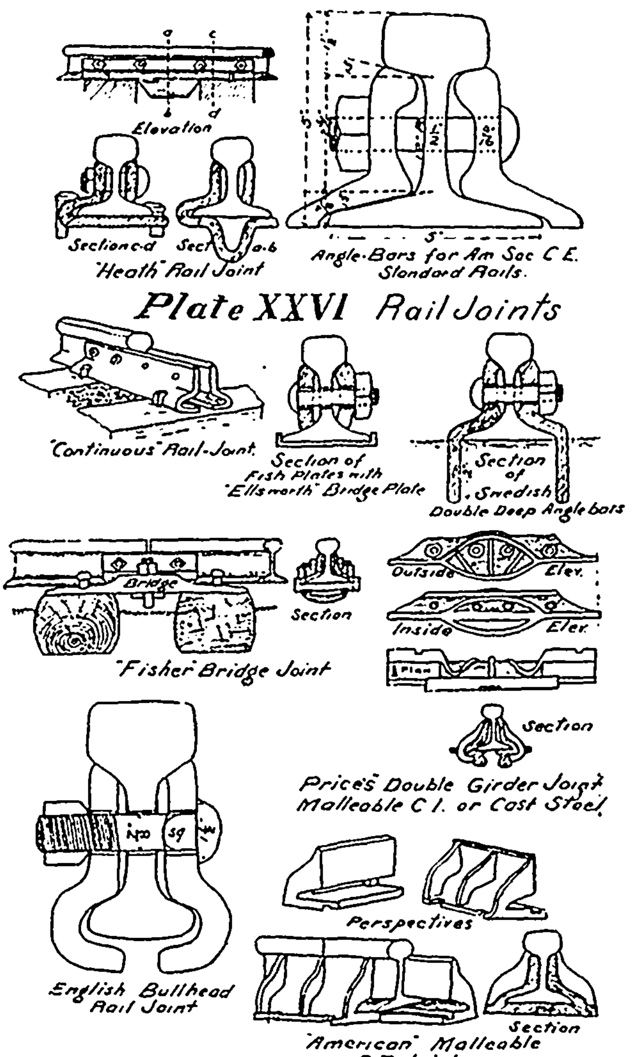
as the wheel loads on drivers get greater, so as to keep a decent track and prevent cold rolling. (Large drivers are not so hard as small ones on track.)

The endeavor is to get a high carbon rail and work it until it is tough and compact in texture in the head.

ARTICLE 5.—RAIL JOINTS.

While great progress has been made in the strength and rigidity of rail joints, they can hardly be considered yet equal to the criterion of simplicity, and of being as strong as the rail itself, and as stiff laterally. Sandberg, by watching the effect of trains on narrow notches cut in



the heads of solid rails, concluded that the lipping-down was due to lack of support of the fibres, and that we may, therefore, not expect to ever obtain a joint so perfect as to prevent this wear entirely. Various joints are shown on Plate XXVI., and also special ones attached to rails on Plates XXIII. and XXIV. Of these the simple fish plates were considered sufficient in early railroad days, when wheel loads were light and speeds not excessive, but, as these increased, the joints could not be kept in surface, and a lower flange was added, giving us the angle bar, which is the ordinary standard form to-day. It is simple, easily attached, etc., and may be used as a suspended joint on two ties with four bolts, or a longer one (44 inches), with 6 bolts, is often used, resting on three ties, and although more expensive, gives better results.

A comparison was made in Sweden between:

(1) Fish plates with Ellsworth base plate.

(2) Angle bars.

(3) Double deep angle bars with 2-inch extension downward between the ties.

The renewals for flattened ends in five years were (1) $6\frac{4}{10}$ p.c., (2) $14\frac{4}{10}$ p.c., (3) $17\frac{6}{10}$ p.c., but as for stiffness they were (1) $\frac{1}{3}$, (2) $\frac{2}{3}$, (3) 1. So that Nos. (2) and (3) were considered superior, particularly owing to their simplicity, but as No. 3 was easily heaved by frost and snow it was considered suitable for milder climates, and the choice rested on the angle bars.

The Fisher bridge joint has been tested quite extensively, and is found to be very stiff vertically, but weak laterally, and its various parts are rather expensive and more complicated than the angle bars. For these reasons it is not likely to find extensive favor. The Churchill joint of N. & W. R. R. is probably the most efficient joint yet designed as far as stiffness, etc., and is intended for use with 60 ft. rails. Otherwise it would be too expensive and complicated for ordinary use. The other joints shown appear to have good points, but are of less tried merit. (Also see *Engineering News*, page 178, Vol. I., 1891, for Paterson rail joint.)

We may expect, ultimately, to obtain a joint as strong as the rail itself, but how simple it can be made is for the future to show.

ARTICLE 6.—RAIL FIXTURES, ETC.

The weak spot of our track is its attachment to the ties by ordinary track spikes. Their heads are often cracked by excessive driving, re-spiking is frequent, and the ties get split and rotten much sooner than they would naturally, and while Greer, Goldie, curved, interlocking and other special spikes are improvements on the dog spike, yet the final solution would seem to be in some positive fastening such as wood screws or fang bolts, such as are used to hold rail chairs to the ties on British roads, and while tie plates and selected oak ties are keeping off the evil day, yet as speeds get higher and engines heavier, demanding a high stiff rail, this must be done by heavy traffic roads sooner or later, either with wooden ties and tie-plates, or with steel ties and bolts.

Tie plates (such as Goldie, Servis, Standard, Sandberg, etc.) will enable roads even with heavy traffic to use soft wood ties and a high stiff rail with narrow base (see N. Y. C. & H. R. R. R. section), and will prolong the life of ties. They are being adopted rapidly, some roads using them on curves only, others for the whole track. Wood screws for holding track are of steel, seven inches long, with thread for $4\frac{3}{4}$ inches, $\frac{3}{4}$ inch diameter, and have a pulling resistance of about six tons. Fang bolts are attached by boring holes through the ties, and screwing the bolts, which have heads on them suitable for holding down a rail, into a nut, with a fang on it. This fang grips into the wood on the under side of the tie, which prevents it turning or loosening.

The vibration caused by passing trains would soon loosen the ordinary nut on the bolts which fasten the angle bar joint to the rails, and, in order to prevent this, many devices have been tried. The double nut is not effective. A gravity lock outside the ordinary nut in the form of an eccentric nut is much better, and Young's patent has been used quite extensively, but the spring nut lock, which consists of one turn or a little more, of a strong steel spiral, with two cutting lips taking hold of angle bar and nut as the nut is screwed on, on top of the nut-lock, is the kind generally used, and being simple, cheap and effective, is likely to remain the favorite kind in use.

ARTICLE 7.—SWITCHES AND FROGS.

Outlines of various designs for passing a train from one track to another are given on plate XXVII., but of course there are various forms of attachments differing in detail only.