the "Phonix column" has been given. They are tubes made from four or from eight sections rolled in the usual way and riveted together at their flanges. (See Plate XV.) When necessary, such columns are joined together by cast-iron joint-blocks, with circular tenons which fit into the hollows of each tube.

To join two bars to resist a strain of tension, links or eye-bars are used from three to six inches wide, and as long as may be needed. At each end is an enlargement with a hole to receive a pin. In this way any number of bars can be joined together, and the result of numerous experiments made at this establishment has shown that under sufficient strain they will part as often in the body of the bar as at the joint. The heads upon these bars are made by a process known as die-forging. The bar is heated to a white heat, and under a die worked by hydraulic pressure the head is shaped and the hole struck at one operation. This method of joining by pins is much more reliable than welding. The pins are made of cold-rolled shafting, and fit to a nicety.

The general view of the machine-shop, which covers more than an acre of ground, shows the various machines and tools by which iron is planed, turned, drilled, and handled as though it were one of the softest of materials. Such a machine-shop is one of the wonders of this century. Most of the operations performed there, and all of the tools with which they are done, are due entirely to modern invention, many of them within the last ten years. By means of this application of machines great accuracy of work is obtained, and each part of an iron bridge can be exactly duplicated if necessary. This method of construction is entirely American, the English still building their iron bridges mostly with hand-labor. In consequence also of this method of working, American iron bridges, despite the higher price of our iron, can successfully compete in Canada with bridges of English or Belgian construction. The American iron bridges are lighter than those of other nations, but their absolute strength is as great, since the weight which is saved is all dead weight, and not necessary to the solidity of the structure. The same difference is displayed here that is seen in our carriages with their slender wheels, compared with the lumbering heavy wagons of European construction.

Before any practical work upon the construction of a bridge is begun, the data and specifications are given, and a plan of the structure is drawn, whether it is for a railroad or for ordinary travel, whether for a double or single track, whether the train is to pass on top or below, and so on. The calculations and plans are then made for the use of such dimensions of iron that the strain upon any part of the structure shall not exceed a certain maximum, usually fixed at ten thousand pounds to the square inch. As the weight of the iron is known, and its tensile strength is estimated at sixty thousand pounds per square inch, this estimate, which is technically called "a factor of safety" of six, is a very safe one. In other words, the bridge is planned and so constructed that in supporting its own weight, together with any load of locomotives or cars which can be placed upon it, it shall not be subjected to a strain over one-sixth of its estimated strength.

After the plan is made, working drawings are prepared and the process of manufacture commences. The eye-bars, when made, are tested in a testing-machine at double the strain which by any possibility they can be put to in the bridge itself. The elasticity of the iron is such that, after being submitted to a tension of about thirty thousand pounds to the square inch, it will return to its original dimensions; while it is so tough that the bars, as large as two inches in diameter, can be bent double, when cold, without showing any signs of fracture. Having stood these tests, the parts of the bridge are considered fit to be used.

When completed, the parts are put together or