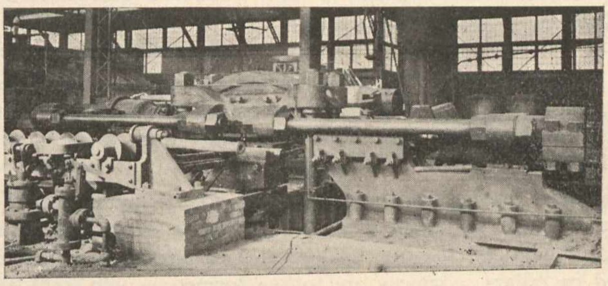
point of the punch was covered with steel from the blank and was ragged, and therefore unfit for a second operation. To avoid the welding the punch was entered first for only six inches, then removed, the cavity filled with hard coal, and the punching operation finished. The punch being sufficiently lubricated by the gases from the coal, did not weld, but was caused to deviate on account of the coal not being evenly distributed around the punch. Solid charcoal iron punches were thereupon tested, but under the great pressure required for penetration they bent before entering the blank, deviating accordingly. If the temperature of the blank was high enough the deviation amounted to only about 1-16 inch, but if the steel was too cold, the punches broke in the outer part, the broken end remaining in the axle. In figuring the strength of these punches 35 tons are required to make them deviate 1-16 inch, showing again the small pressure required for punching. On the other hand, this deviation necessarily followed from the fact that the length of the punch was eight times its diameter, whereas it should not be over five times, according to accepted authority for cast iron. It may be twelve times the diameter for steel, or even more, according to percentage of carbon and treatment. As a result of these experiments high carbon Bessemer steel containing 0.9 to 1 per cent. carbon was adopted and the punch was found to be very stiff. To overcome the difficulty of the welding the ends of the punches were provided with drop forged steel caps. These caps rest on the point of the punch, fitting the same neatly, and are a little larger in external diameter than the punch, in order to avoid friction between punch and the blank, resulting in a minimum of pressure required for penetration. By the pressure the caps are welded to the blank. The punch, being protected from injury, is very easily withdrawn, and, after cooling, it is ready to receive a new cap for the next operation. This arrangement proved to be very satisfactory and practical. The caps can be made very cheaply, drop forging same from steel plates or skelpt, preferably made of axle steel. In order to avoid heating up of the punches the same are preferably black leaded, this being carried deep into the blank, the pierced hole having a greater diameter than the punch, owing to the slightly larger size of the cap.



Mercader Hydraulic Axle Press.

The material employed for the matrix dies is best machine cast iron, water cooled to prevent a change in the shape and dimensions of the cavities. The dies show very little signs of wear and tear, and it appears that they will withstand the punching of a great number of axles, since the slight wear only smooths the inner surfaces of the dies. Further experiments in this direction might lead to the adoption of cast steel dies. To remove the axle readily all corners of the die are tapered and to prevent sticking the cavities are preferably black leaded.

In order to cover all possible conditions and emergencies in the manufacture of these car axles the press should be designed for about 350 to 400 tons, total pressure being about 1,500 pounds hydraulic pressure per square inch. To lengthen the life of the punches and avoid liability to their injury by the heat, the piercing should be carried out very rapidly. This can be accomplished in four to five seconds by connecting the hydraulic cylinders and the accumulator with a correspondingly large pipe line, and by using specially designed four-way operating valves. The auxiliary parts of the press require for their operation a hydraulic pressure of 500 pounds per square inch. The quantity of water needed is comparatively small.

With the experimental plant erected at Homestead, the time required to make one axle, all operations included, did not exceed two minutes. Allowing two minutes for cleaning and black leading the dies and for cooling and capping the punches, the capacity of one press will be 15 axles per hour, or 300 axles, 5½ by 10-inch journal, per 20 hours, which is fully three times the quantity accomplished with one hammer by the best American practice. The number of men required to operate the press remains the same as needed at the hammer to forge five 5½ by 10-inch journal axles per hour. The machine produces a strong and light axle which contains the cardinal combination desired—namely, minimum weight and maximum strength. The axles made have more resiliency than the present type, and are not liable to fracture from sudden strains. Their use in railway car construction results in material economy, not only over solid axles, but over any other species of hollow axles.

Broadly speaking, hollow axles are old, but such axles have been made either by casting them the shape desired or pressing them hollow throughout and then forging on a mandrel or by boring out solid metal. These methods are each objectionable, because they either fail to produce axles of sufficient strength and lightness or are too expensive for general adoption. The end portions of this axle are, of course, hollow, the cavities extending beyond the wheel seat, but this is an advantage because the forging action which is produced by the entrance of the punches greatly compacts and strengthens the metal and renders the axle less liable to break. The combination of hollow ends with solid centre has the advantage over hollow axles that all requirements for the drop tests and for torsion, produced in curves, are fully covered. It is obvious that a hollow axle will soon deform in the centre under the drop test, rendering the test uncertain.

It will be understood that heretofore, in the finishing of an axle, it has been greatly weakened by cutting away the outer skin, which has been compacted by the forging operation; but in the use of the present system a tough dense skin is produced on the interior of the axle by the forging action of the punches, and this skin is not cut away, but remains a permanent element of strength, and the tough external skin is cut away only at the end portions. It is unnecessary, as heretofore, to machine the axle throughout its entire length, for by the dies it is compressed to exact length and made so true that it is sufficient if only the journals and wheel seat portions are turned or machined.

The advantages of a hollow pressed axle may be summarized as follows:

1. The axle has a perfect form; its shape can be best adapted to resist the strain to which it is subjected with the least amount of metal, combining minimum weight with maximum strength.

2. The forging effect being carried out throughout the material, both internally and externally, the material is found to be far more homogeneous than solid axles made in the usual manner, segregation is destroyed and, consequently, the axle is much more reliable.

3. The journals, being highly compressed, will in finishing attain a more highly polished surface, thereby minimizing the friction, resulting in economy of draft.

4. The journals, being hollow, will remain cooler and permit the storage of a considerable quantity of oil, removing herewith the chief cause of hot journals, also economizing materially in the expenditure for lubrication.

5. No straightening after punching is required, the axle being as straight as the die, thereby eliminating entirely the injurious effects of the gagging operation.

6. No centreing, no cutting of the ends, no rough turning is required, thereby saving considerable in finishing labor and increasing the finishing capacity of existing plants.

7. The punching of treble the amount of axles as compared with forging with an equal number of hands, resulting in saving of forging labor.

8. Considerable saving in steam consumption and fuel.

9. The detection of a defective axle without performing