liquid steel, so hot that it will melt a steel bar of 4" square section and fuse with it to one homogeneous mass.

The essential characteristic of Thermit is that it welds by fusion, and by reason of this fact, calls for the foundryman's experience more than the blacksmith's. Its success depends on the proper material, shape and condition of the mold.

The mold into which the contents of the crucible are run must be of refractory material. The general instructions must, of course, be broad and cannot go beyond stating that a mixture of equal parts of sharp sand and ordinary brickmakers' clay has given satisfaction. The formula has been varied sometimes, according to local conditions, in some cases flour, in the proportion of 6 to 100, being used as binder for the sand. Some shops have already evolved their own particular formulas, which they treat as secret. The mold always must be dry—burnt dry. In some cases, for instance, at the Elkhart Shops of the Lake Shore & Michigan Southern, the difficulty has been overcome by using fire-brick cut down to size. This certainly overcomes the question of drying molds.

The shape of the mold must next be considered. It must be so constructed that the steel flowing down through the gate will not strike direct on to the casting or forging, but will flow underneath the lowest part and rise around and through it. What is required is good circulation for the Thermit Steel. It must flow around all the welding surfaces, and as it gets chilled in contact with these, it must be driven up into a riser and be followed by a sufficient supply of fully heated Thermit Steel to effect the actual weld, which takes the shape of a collar or reinforcement, cast on or over the fracture.

The mold must therefore allow (1) for a gate, (2) for a collar, shoe or other reinforcement on the surface of the welded piece and overlapping the edges of the break or joint, (3) a riser, (4) a skim gate, to prevent the slag from getting mixed with the steel.

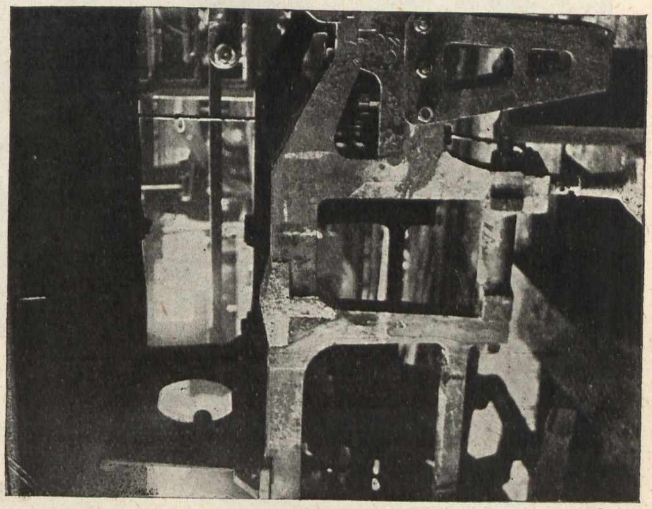
The formula for calculating the amount of Thermit must also allow not only for the cubic space of this reinforcement, but further, for again as much Thermit, to supply the contents of gate and riser.

These are the general instructions for welding, for instance, LOCOMOTIVE FRAMES—a problem which some thirty railroads in this country have investigated with more or less success. These frames are of wrought iron or cast steel, and vary from 3½ x 3½ to 5" x 6" in section. They are very liable to break, and their repair without dismantling the engine means a very large saving per engine. It has been stated that an engine, the frame of which is repaired in the forge, remains a fortnight out of commission, and the actual weld costs $250 to $300. The work by Thermit can be done comfortably in three or four days, at a cost of about $50.

Welding Loco Frame: Ready for Ignition.

In reply to a circular letter of inquiry, about twenty railroads have supplied data, which, however, cannot be considered complete, as some of the most regular and extensive users of Thermit did not care to supply the information asked for.

The first successful weld it has been possible to get a record of was made by Mr. Sanderson, Superintendent Motive Power, Seaboard Air Line, on October 19th, 1904. This engine has continued in service ever since. It is one of eight engines welded on that road which has given satisfaction, which speaks highly for the care used at the Portsmouth shops in handling a new and therefore difficult problem.



Loco Frame: Welded in the Jaw.

Another series of successful welds is reported by the Boston & Albany Line, where Mr. Fries welded five engines quite successfully—one being in continuous service since the end of November. One, welded in the jaw, broke again, but four inches away from the weld.

Of late the Lake Shore & Michigan Southern has shown great interest, its perseverance has been crowned by success in some very good welds at their Elkhart Shops, about which Mr. Webb read a very interesting paper at the last annual meeting of the American Foundrymen's Association, giving a full account of each step in the operation. On a preliminary tests, a welded bar 2½ x 2¾ stood a pressure of 50 tons on supports 20 inches apart, before breaking, and that, after two sides of the reinforcing collar had been machined off.

In all there are records of thirty engines with welded frames that have been in service for three months or longer. Failures are recorded only in isolated instances and are assignable to three different reasons:

First, wrong construction of mold.

Secondly, insufficient Thermit; in other words, insufficient circulation—therefore, insufficient fusion.

For those familiar with the process, a weld that breaks on account of lack of cohesion at the welding surface is attributable under all circumstances to lack of experience or care, except in one particular case.

It is possible for Thermit welded frames to break in spite of proper execution of the work. The original break is due, in the first place, to a structural defect. With the break in such a position as to necessitate the entire removal of the reinforcing collar, it is too much to expect the mere bridging of the broken ends by Thermit Steel to overcome this innate weakness.

An important factor in success in welding locomotive frames is to allow for equal shrinkage of parallel parts; also, wherever possible, to spread the ends apart in order to let them come back when the iron begins to set.

Another operation of interest to railroad men is the welding of spokes of drivers.

In making tests of the metal of such welds, the Chicago, Milwaukee & St. Paul R. R. found a tensile strength of 93,900 lbs. per square inch. The analysis agreed with that of the Pennsylvania R. R., with the exception of Manganese, which in this case was only 0.74.