deg. F. for timber consisting chiefly of sap-wood. By prolonging the process so that the partial vacuum and the compression each extended to the period of sixty minutes, the temperatures increased to 149 deg. F. for a sleeper chiefly of heartwood, and to from 149 deg. to 158 deg. for three sleepers chiefly of sap-wood. By the preservative method cited above the temperature attained in the interior of the sleepers was in no case very high, only exceeding 140 deg. F. under quite exceptional conditions that are never realized in ordinary practice, and as a general rule the interior temperature was in the neighborhood of 122 deg. F.

These facts being satisfactorily established, we are justified in arguing that as absolute sterilization cannot be assured at temperatures below 240 deg. F., the temperatures reached in the interior of timber during treatment by the process here in question—and by other processes of similar character and with similar temperature limits—cannot possibly insure the sterilization of destructive organisms. It may be the fact that the outer portions of the timber are protected by the antiseptic liquid absorbed, but the inner portions to which the antiseptic does not penetrate are not benefited. If spores exist in such parts they cannot be

killed by the inadequate temperatures given by low-pressure steam, and their activity is not reduced by the antiseptic substances ordinarily used, owing to the failure of the liquid to penetrate to a sufficient distance beneath the outer surface of the wood.

To insure absolute sterilization the timber must be heated throughout—preferably by saturated steam—to the temperature of at least 240 deg. F., and this temperature must be maintained for not less than fifteen minutes, or the timber must be completely saturated with a solution capable of destroying living organisms and spores.—The Builder.

COPPER REFINING MACHINERY.*

HOW ORE IS HANDLED BY INGENUOUS MACHINERY.

BY DAY ALLEN WILLEY.

THE copper-bearing ores of the United States are mined principally in three sections of the country—on the Keweenaw peninsula of Michigan adjacent to Lake Superior, in Montana, and in Arizona. So ex-

the methods employed in earlier times in extraction of the metal. It may be needless to say that the stamp mill exerts its force through a mass of iron or steel which falls upon the ore, crushing it into small

The more modern type of jig is usually a revolving screen, which by its movement separates the material into different sizes, when it is carried into launders. This name is appropriate, since through

GENERAL INTERIOR VIEW OF ORE-SEPARATING PLANT, SHOWING CONVEYORS AND JIG.

HEADS OF ORE CRUSHERS IN A MICHIGAN MILL.

FEEDING A GYRATORY CRUSHER FOR TREATING ORE.

REVOLVING SIZING TABLES IN MILL.

COPPER REFINING MACHINERY.

tensive is the Lake Superior production, that from this region comes fully 25 per cent of the copper output of the United States. The Calumet and Hecla plant alone crushes over 6,000 tons of ore daily.

As much of the copper is found in formation containing silver, sometimes gold, the machinery designed in recent years for separating the metals has been arranged with a view of reducing the percentage of waste to a minimum. From the time the metal is taken from the mine in the form of ore until it is freed from all foreign matter, it is subjected to several processes which may be embraced in two distinct groups. One is its preparation for the smelter, while the other comprises the smelting and refining. Although several inventions have been perfected for reducing and concentrating the ore, the preliminary processes are not radically different in principle from

fragments and powder. Mechanical power is only employed in the stamp mill to lift the crushing head, as it acts by the force of gravity. In its operation the stamp mill resembles the familiar pile driver, the stamp descending through a groove. The stamp is the principal process employed for the first crushing, although in some districts in Michigan the gyratory mill has been introduced. As a rule, however, this process is more expensive unless steam or hydraulic power can be obtained at a very low cost. Prior to passing through the stamp mill, the ore is first assorted by being fed from the storage bins or mine cars upon screens composed of iron bars set about one inch apart. The material which falls through these "grizzlies" or "fines" passes directly upon what are really the first set of jigs. The ore which remains upon the "grizzlies" is conveyed to the stamp or gyratory mill, lumps too large to be taken in by the mechanism being broken up by sledge hammers.

the launders flows a current of water diluting the material as it passes to the next set of jigs. These consist of beds of sand held by screens moved by currents of water passing upward and downward. Another form of jig is a screen which is also movable, but pushed up and down in a tank of water. In either case the operation separates the ore according to its specific gravity. A further separation, however, is accomplished by treating the powdered ore on circular tables. As these revolve, a film of water flows over their surface. This last operation of "sizing" generally removes most of the waste material which may remain. It is carried away in solution, leaving the mineral in the form of powder or concentrate.

While the Calumet and Hecla plant is notable for its enormous capacity, that at the Anaconda works in Montana is also one of the largest in the world. One series of six stamps alone has a crushing capacity

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

of nearly 2,000 tons daily. Each stamp shoe weighs 500 pounds, yet such is the extent of abrasion caused by contact with the ore, that frequently they must be replaced after a service of but three days. These stamps are among the most powerful in the country, the total crushing weight exerted by each being no less than 30 tons. At the Michigan plant the concentrating machinery is entirely separate from the

crushers. As fast as the material passes through the stamp mill it is transported to Lake Linden, a distance of four miles, where it is reduced to concentrates.

As in the modern coal breaker, advantage is taken of the force of gravity in handling the ore through the various processes. The grizzlies are usually placed at a considerable elevation above the other appar-

atus, so that the "fines" will pass by gravity to the first series of separators, and the larger fragments can be conveyed to the stamps in the same way. The product of the stamp mills is taken to the jigs by means of inclined conduits, so that when the copper is ready for the smelter, it has passed successively from the top to the bottom of the plant where it is being treated.

A NEW MOUNTAIN LOCOMOTIVE.

AN IMPROVED SYSTEM WITH INCREASED ADHERENCE.

A SYSTEM of traction which is designed specially for use upon heavy grades has been brought out in France within a recent period. The principal feature of the system is the use of a type of locomotive in which a third rail lying between the main rails of the track is clasped between wheels or rollers which thus serve to give an increased adherence to the locomotive and in this way a comparatively heavy train can be taken up a steep grade.

Speaking of different methods which are in use at

FIG. 1.—SUPPLEMENTARY ADHERENCE MECHANISM.

present, we find that a locomotive provided with a tender is used oftenest upon the main trunk lines, and in this way it is possible to draw a weight representing two or three times the weight of the engine upon grades of 2.5 or 3 per cent. In the case of a locomotive tender we may find that the locomotive is able to draw an amount equal to its own weight up a 5 per cent grade. Coming to electric traction, where

motor cars are used which generally have a light weight, the limit of the grade may now reach as high