spheres 30 centimeters in diameter. When the two arms of the oscillator system, *c*, were charged to a sufficient potential the air-gap, *d*, was disrupted and a series of sparks filled the gap during the period of the oscillation of the electric charge. This set up in the surrounding medium stationary electric waves, also discovered by Hertz; these waves Hertz detected and measured by means of a circlet of wire having a minute spark-gap between its terminals, as shown in Fig. 3, *B*. The action of these waves in other circuits had been observed before Hertz, but the effects were attributed to electro-magnetic induction.

These are the fundamental principles underlying wireless telegraphy and upon which the whole art of syntonic methods is based; the working out of these laws constitutes the applied science of electrical resonance and in the following paper its relation to syntonic wireless telegraphy will be discussed.

(To be continued.)

THE BUILDING OF AMERICAN LOCOMOTIVES.—II.

In our issue of June 7 we pointed out that among the many great industries of America, none have more strongly marked national characteristics than the locomotive industry, and we traced the history of American locomotive building as illustrated by the growth of the American locomotive in the Baldwin Works from "Old Ironsides" of 1832 to No. 20,000, of 1902. The present article is devoted to a description of the great establishment in which an average of 1,500 locomotives a year is constructed, and from which they are shipped to almost every country in the world.

THE FOUNDRY.—The locomotive castings are made in a large foundry, measuring 80 x 400 feet. The most important castings are those of the cylinders and wheels, in addition to which there are the numerous less important fittings that enter into the make-up of a locomotive. The raw material consists of new pig iron and old stock, the latter including any good gray iron, such as old locomotive cylinders, grate bars, axle boxes, etc. The materials are melted down in three 50-ton cupolas, the output of which varies from 100 to 150 tons per day. The furnace mixture is in the proportions of 2,000 pounds of pig, 2,000 pounds of scrap, 1,750 pounds of coke and 50 pounds of marble. The foundry is served by seven jib cranes and two overhead traveling cranes.

THE CYLINDER SHOP.—The cylinder castings are cleaned and taken to a large shop devoted especially to the finishing of cylinders. One of the most interesting machines in this department is a special boring mill, designed for boring and facing the castings for the four-cylinder compound locomotives, of which this firm is making an ever-increasing number. Each casting consists of a high and low pressure cylinder, and a cylinder for the piston valve, together with half of the saddle. The mill is arranged so that the three cylinders may be simultaneously bored and faced, with a great gain of time and the certainty of accuracy of the finished work.

WHEEL-LATHE SHOP.—The wheel castings, which are cast in one piece, the rim being formed segmentally to allow for cooling strains, are taken to a special wheel-lathe shop, where the rims are turned, and the hubs are bored and faced. The wheels are forced onto the axles by hydraulic pressure and the tires are shrunk on. The axle ends are turned to an even size, and the hole in the wheel hub is bored less in diameter, by an allowance of three one-thousandths of an inch for each inch in the diameter of the axle. The two pieces are then put in a hydraulic press and the axle is thrust into the hub with a pressure which commences at 10 tons and finishes at as high as 125 tons. The tires are maintained on the rims by the initial tension set up when they are shrunk into place; but the tires of express engines are further secured by a retaining ring.

THE FORGE.—One of the most interesting departments is the forge, where raw material in the shape of wrought iron scrap, such as bolts, rivet-heads, etc., is piled up in small rectangular heap on boards, and raised to a melting heat in the furnace, from which it is taken out and hammered by steam hammers into slabs. The slabs are then put together in couples, heated and welded, the process being repeated until full-sized billets are formed measuring 8 x 8 inches by 3 feet in length. The object of this heating and reheating is to secure that thorough working of the material which is essential to the production of the highest grade of wrought iron and steel. A feature in the forge is the large battery of overhead boilers which is carried above the furnaces, the waste heat from the latter serving to raise sufficient steam to supply the whole forge shop.

CONNECTING-ROD ROOM.—A marked feature of this great establishment is the attention that has been paid to the question of labor-saving, both as regards the machines employed and the broader question of general shop management. Evidence of this is seen in the devoting of separate buildings, or of separate floors in buildings, as the case may be, to the construction of particular parts. Thus, we have already referred in this article to the wheel-lathe shop, the cylinder shop, etc. In fact, almost every detail of the locomotive of importance is machined and finished in its own particular room. One of the most interesting of these departments is the connecting rod room, where the rough forgings for the side and main rods are milled, planed, finished milled, and polished. The connecting rods are forged of mild steel. They are first centered in a lathe, then scribed out by templates, planed down to proper width; the ends milled to shape, and where they are of the new I-section, the recesses are worked out by milling the two ends, and planing out the intervening material. The brasses are forced in place by hydraulic pressure.

TENDERS.—The construction of the tenders is carried on in a separate building, one floor of which is devoted to the construction of the trucks and frames of the tenders; another floor to the laying out of the plates and the shearing and punching of the same, while on another floor the tenders are erected.

THE BOILER SHOP.—Unquestionably the boiler is today the portion of the locomotive which is receiving the most attention from locomotive designers. It is well understood that the efficiency of the locomotive depends upon the ability of the boiler to produce abundance of dry steam of the desired pressure when the engine is being worked to its fullest capacity. Steel plate is used exclusively in the Baldwin boilers, and it is received at the works in sheets of various thicknesses and sizes, some of which are as much as 20 feet long. The sheets are first marked out by standard gages, although in cases where they have to be flanged, the flanging is done previous to the template work. The rivet holes are then punched or drilled, as required by the specification; the holes of the boilers of foreign locomotives being invariably drilled, while American specifications usually call for punched holes. The boiler shop is replete with a large assortment of drills and punches, which are driven by several electric motors. Flanging as far as possible is done by hydraulic presses, one of which is shown in the accompanying illustrations. This machine is operated by two accumulators with a maximum capacity of 365 tons. The plate is heated in the furnace and the flanging is done between two suitable forms, one clamped to the lower, and the other to the upper table. Dome rings, smokeboxes, tube sheets, etc., are all formed up on this machine with great accuracy and speed. After flanging, the plates are returned to the boiler shop, where the edges are planed where necessary, or chipped with a chisel. The plates for the barrel are trimmed in a shearing press, their edges are planed, and they are then rolled to the proper curvature in the bending rolls. The boiler is now assembled for the riveting machines which, in these works, are operated by hydraulic power. The riveting dies are carried at the upper ends of two massive upright jaws which, in the larger machines, are tall enough to allow the boilers to be let down by overhead cranes, with the line of rivets between the jaws. The riveting commences at the top and is carried down to the bottom of the boiler by simply lifting the latter by the overhead traveler.

ERECTING SHOP.—The erecting shop is a fine building 160 feet wide and 337 feet long. It is divided longitudinally into two bays, each of which is served by two electric traveling cranes of 50 and 100 tons capacity. Three of our first page illustrations are taken in this shop, and they represent various stages in the erection of some of the extremely powerful freight engines which this firm is now turning out, the last of which, built for the Santa Fé Railroad, is considerably the heaviest locomotive in the world. Limitations of space forbid any detailed account of the method of erection, but briefly stated, it is as follows:

First the cylinders are set up at the height above the rails which they will occupy when the locomotive is completed, and the attached saddle is prepared for the setting of the smokebox. The engine frames are then erected and lined up. Next the complete boiler is lifted by one of the overhead cranes and placed in position, the boiler being bolted to the saddle. The tubes are then inserted and expanded. Then the driving wheels are put in place, or rather the boiler and frames are raised by the overhead cranes and lowered down upon the wheels, the journal boxes and the axles being guided in between the pedestals. At this point the engine has the appearance shown in the upper left-hand cut on the front page. Meanwhile the various boiler fittings have been put in place and connected up. The next step is the water test in which hydraulic pressure is applied at about 266 pounds to the square inch, the working pressure being 200 pounds to the square inch. Then the water is removed from the boiler and it is tested with steam at 10 per cent in excess of the working steam pressure. The connecting rods, link motion, etc., are assembled, the valves are set and the eccentrics keyed to the main axle. Meanwhile the boiler is being lagged, the same protection being placed over the cylinders. By this time the locomotive presents the appearance shown in the large cut at the bottom of the front page. The sheet iron jacketing is then placed over the boiler and cylinders. Then follows the engine test, the boiler being connected to a stationary steam plant and the engine run under steam. After the painting and various finishing touches the locomotive is ready for shipment.

THE TESTING ROOM.—Before closing, a word should be said with regard to the testing department, the work of which may be said to lie at the very foundation of the excellence which characterizes the output of this establishment. All material that enters the works is subjected to both a chemical and physical test. Every delivery of plates is numbered, as is also every plate in each boiler. When a set of plates is being shipped, say from a mill at Pittsburg, a piece is previously cut from every plate and expressed to the Baldwin testing department, where it is tested. The rejected test pieces are sent to the shipping clerk, and as the plate shipment comes in, the corresponding plate is returned to the makers. The boiler plate is of open hearth steel, of a tensile strength of 60,000 pounds to the square inch, and it must show an elongation of 25 per cent in 8 inches. By the careful system adopted of numbering every plate in every boiler and keeping a record of the test on each batch of plates, it is possible, in case of a boiler explosion, to refer to the test and obtain full data regarding the plate.

It is interesting to notice, in closing, the great increase in weight and cost of locomotives that has taken place during the past twelve years. In 1890 the average weight of a locomotive was 100,000 pounds, and its average cost $8,000. In 1902, the average weight is 150,000 pounds, and the average cost $12,000, the increase in cost having kept pace very closely with the increase in weight, and this in spite of the fact that labor and materials have risen very considerably in cost.

Imitation Meteorites.

Genuine meteorites are curiosities highly prized by museums and scientific collectors. Prof. St. Meunier, of the Natural History Museum of Berlin, paid as much as $5 per gramme for a meteorite. It is, therefore, conceivable that sharp practices should be resorted to by dealers in scientific curiosities. A band of meteorite counterfeiters was recently captured and considerable evidence obtained of very curious and ingenious methods for seducing the gullible collector. The members of this band were Corsicans. It was their practice to obtain natural rock resembling meteorites as closely as possible and then to burn them in order to produce the black crust which is one of the earmarks of every genuine meteorite. The pieces of rock were coated with lampblack, dissolved in molten sulphur. It seems, however, that this method was so crude that the deception was easily discovered, and the men were forthwith arrested.

Parisian Trees.

Paris is said to lead the world in the culture of city trees. The success of the French capital is due not so much to an admirable soil climate as to a well-organized system of caring for the trees.

In large nurseries young trees are grown and prepared for the Parisian streets. The culture of the soil is elaborate. From the very beginning the trees are pruned and staked to compel a straight growth. By frequent transplanting the roots become so hardened that they are enabled to withstand injury due to transportation. When a tree is sufficiently large, it is set out in the streets with the same care that was lavished upon it in the nursery. Often the cost of planting a single tree is $50. Whenever a storm destroys the city trees the nursery can be immediately drawn upon for another supply.

The Current Supplement.

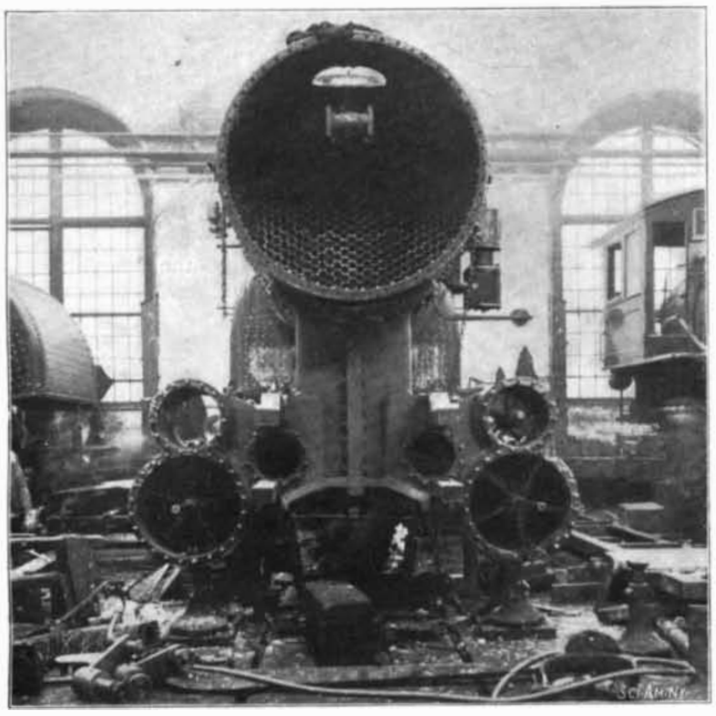
The current SUPPLEMENT, No. 1390, opens with an interesting article on the Ruins of St. Mark's Campanile, giving some of the reasons of its fall. In a long and very complete article M. H. Dastre discusses the rôle of mosquitoes in the dissemination of diseases. Another article of interest, is that of Mr. Otis Mason, upon the Harpoon—Foremost Among Savage Inventions, the first paper of which appears in this issue. The subject of Electrolytic Production of Metals, with Special Reference to Copper and Nickel, is exhaustively treated by William Koehler, of Cleveland, Ohio. Among other articles of interest is one treating of Horned Lightning Arresters with Iron Framing; also a description of the Siemens and Halske Process for Purifying Drinking Water by Ozone. The usual Trade Notes and Recipes and Suggestions by United States Consuls are given.

Our attention has been called to a typographical error in the article on "A New Artificial Fuel," which appeared on page 92 of our issue of August 9. The statement is made that the calorific value of synthetical coal is represented by "1,300 degrees British thermal units." This should read "13,500 British thermal units."

SCIENTIFIC AMERICAN

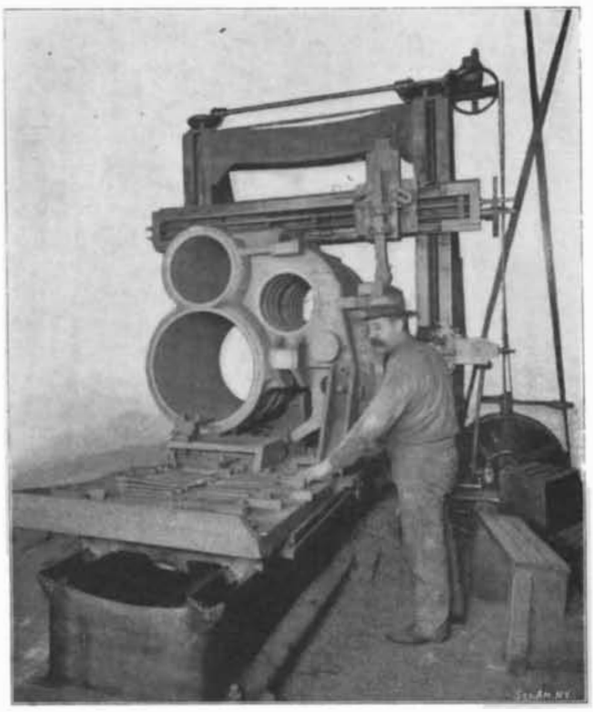
[Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1902, by Munn & Co.]

Vol. LXXXVII.—No. 8.] ESTABLISHED 1845. NEW YORK, AUGUST 23, 1902. [$3.00 A YEAR. 8 CENTS A COPY



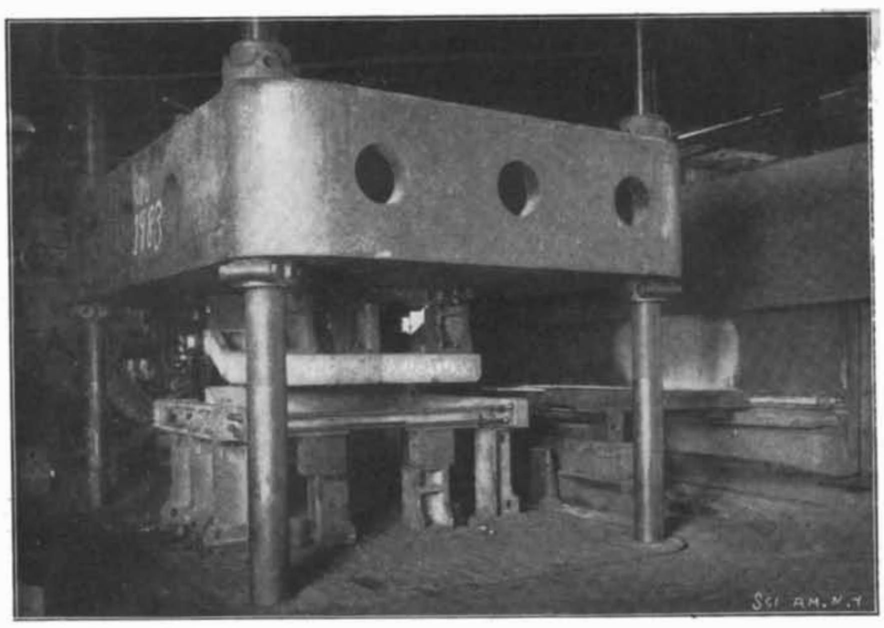
Second Stage of Locomotive Erection: Cylinders, Frames and Boiler in Place.

Front View of the 20,000th Baldwin Locomotive Showing Arrangement of the Four Cylinders and Two Piston Valves.

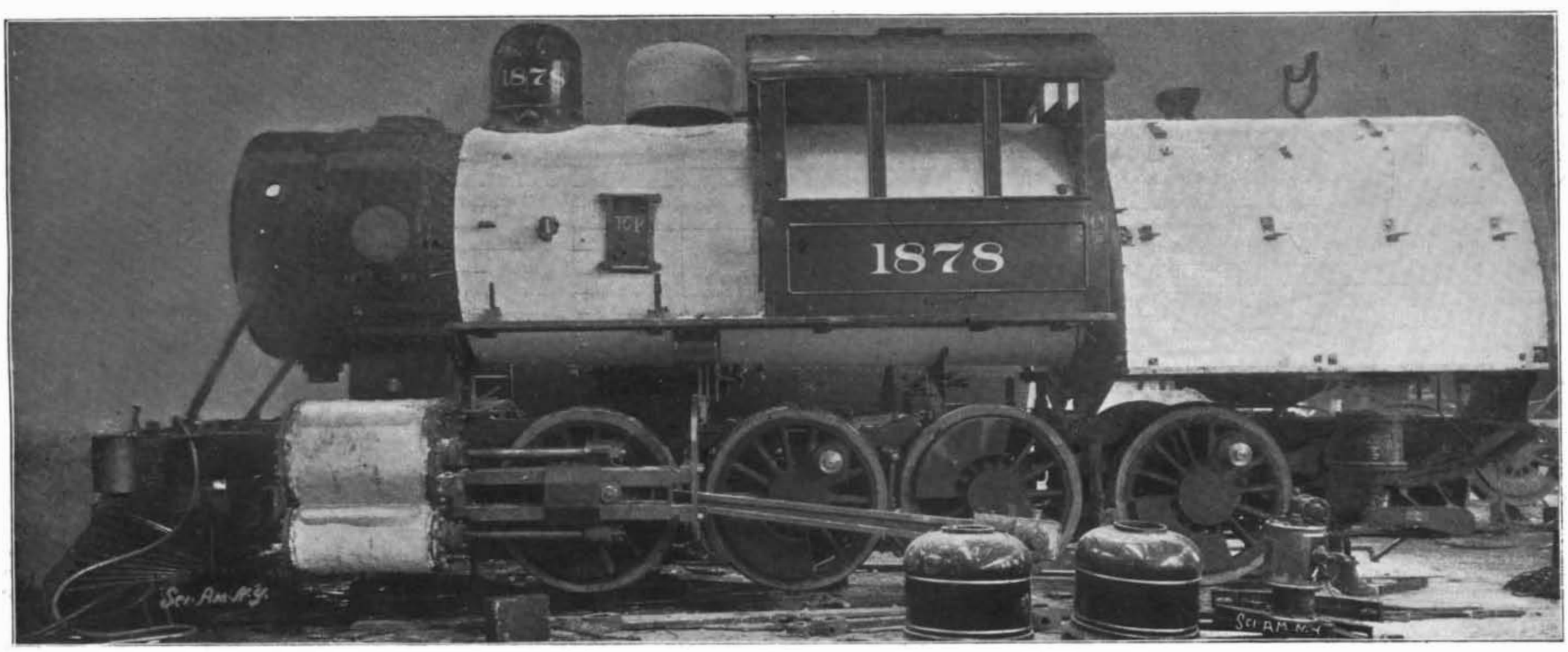


Planing the Bearings for the Frame Rails.

The Boiler Shop.



Hydraulic Press for Flanging Boiler Plates, Etc.



Fourth Stage of Locomotive Erection: the Boiler and Cylinders Lagged with Magnesia.

THE BUILDING OF AMERICAN LOCOMOTIVES—II.—[See page 121.]