THE "CIRE-PERDUE" PROCESS OF BRONZE CASTING.

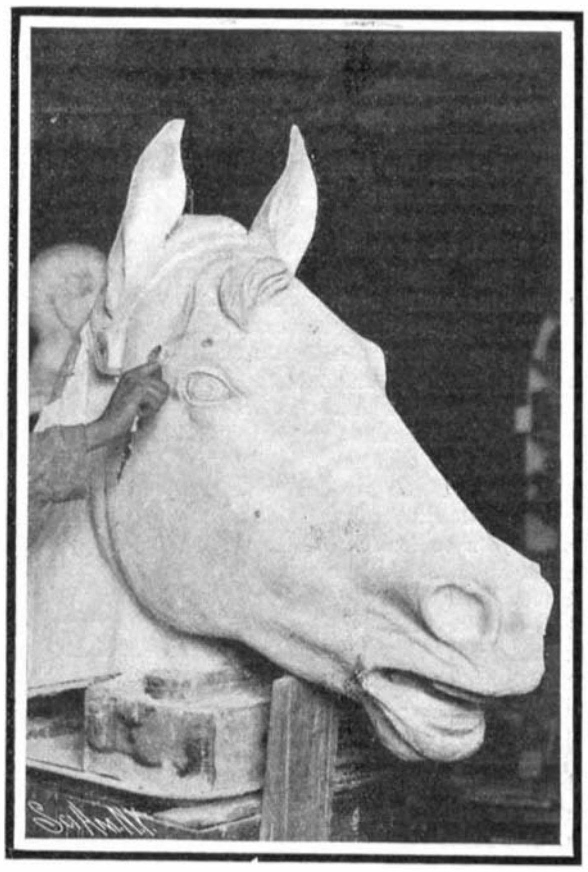
In very many of the artistic sciences and crafts we in this country are still behind the Europeans. That this is the case is of course easily explained by our comparatively short national life and the fact that the artists and craftsmen of the Old World have been perfecting themselves and developing the processes of their sciences for hundreds and sometimes thousands of years. In the casting of architectural and art bronzes is this generally, and with truth, believed to be the case. It has only been within a few years that we have been able to approach the French, Italian, and Russian bronze work. Even to-day work that can fairly be considered the equal of any done in Europe is accomplished by but few firms in this country; and the success of these companies is entirely due to the introduction of the "cire-perdue" process of making bronze castings. This process, while it has been in use in Europe for hundreds of years, was not introduced in the United States until about a decade ago.

While a similar though much cruder method was in use by the ancient Greeks and Romans, it was developed to essentially its present state by the great Florentine goldsmith and bronze worker, Benvenuto Cellini, about the middle of the sixteenth century and has remained practically unchanged to the present day.

The "cire-perdue" process differs radically from the common or sand casting in several ways, and the latter can in no wise compare with it. Its principal advantage is that no matter how complicated or involved the original may be, the bronze reproduction can be cast in a single piece. This does away with assembling the separately cast bronze pieces, with the consequent inevitable traces of the joining. Further, there is no tamping of sand in the mold, with the danger of destroying detail, and finally, a complete casting takes about half as long to make by this method as by the other.

Though the sculptor usually carries out his conception in clay or wax of the same size as the intended bronze, it is sometimes inconvenient, especially if the statue is to be of heroic size, to do this, and consequently the artist's original is frequently much smaller in size. As, however, full-size plaster casts are necessary in this or any other process of bronze casting, a full-size clay model must be constructed from the small original. The illustrations show the manner in which the whole or the parts of a model are enlarged.

When the original or plaster replica is received from the artist, the first step in the "cire-perdue" process is to make a plaster or gelatine mold or "negative." Within this negative a hollow wax figure or positive is now built up, the wax being applied with a brush till it is of the thickness that the finished bronze is to be. This part of the process, as is easily seen, is analogous to sand molding, and the wax figure must be made in separate pieces whose size and number are determined by their shape; for instance, if a half-closed hand is to be molded, the fingers and the body of the hand would have to be separately reproduced and afterward assembled, as otherwise it would be manifestly impossible to remove the pattern in one piece without destroying the mold. The analogy ceases with the assembling of the separate wax pieces. The complete figure is retouched as much as necessary, and, as the medium is wax, by using heat in the assembling the joints can be absolutely done away with, so that we have an exact wax likeness of the artist's original. A great advantage of this method is that, if he desires to do so, the artist can change or retouch the wax figure as much as he pleases. The wax is sufficiently hard to permit handling, and will take the most delicate impression.



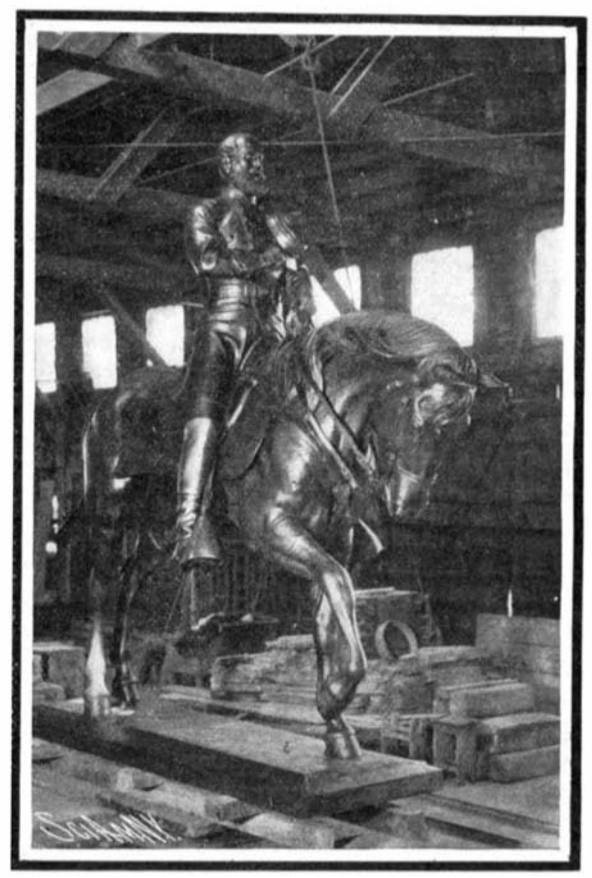
Retouching Plaster Model.

Finishing Model of General Porter.

Putting on Channels, Gates, and Cores.

Sand Molding.

Completely Assembled Wax Positive or Pattern.



Finished Bronze.

THE "CIRE-PERDUE" PROCESS OF BRONZE CASTING.

The next step is the making of the final mold for the metal. This is made of a composition, liquid in form, that hardens in a few minutes after its application. This composition is poured around the wax figure and, as can be easily understood, makes as exact a mold as can be produced, and, moreover, entirely without ramming or tamping. At the same time an outer shell of a coarser composition is built up around the mold to give it greater strength. An opening or two is left in the hollow wax figure so that the composition may be poured into it to form the inside core. Bronze rods are driven through the wax at several places, projecting on the inside as well as the outside, in order to hold the outer and inner cores in their proper relative positions on removing the wax. Before the completion of the outer core, wax rods or bars, that later form channels for the metal or vents, are attached to the wax figure wherever necessary, all leading to one main channel in the upper end of the mold. The enveloping of the figure with the composition is now completed, and the mold placed in an oven and baked over a slow fire. Under this treatment the wax runs out, leaving a mold of the complete figure, while at the same time the composition hardens. The mold is now ready for running the molten metal.

The casts come from the mold in an almost perfect condition, the minutest detail being as clear and distinct as if chiseled by hand. Beyond removing the channels and vents, which of course have been filled with metal, and brushing off the particles of the hardened composition with a stiff brush, the figure requires no attention other than the usual final coloring or patining, which is done with acids and chemicals.

In the "Cire-perdue," freely translated "lost wax," process as used by the Greeks and Romans, an inner core was made roughly of the desired shape and covered with a layer of wax. In this wax the artist modeled the figure and then the outer core was put on surrounding it. The mold was then baked, the wax melting out, and the metal run in. While this made an exceedingly good bronze of the artist's conception, it did not permit of making more than one and was consequently impracticable for modern use, till the genius of Cellini developed the process to its present state.

For the information contained in the above account, we are indebted to the courtesy of the Roman Bronze Works, of Greenpoint, Brooklyn.

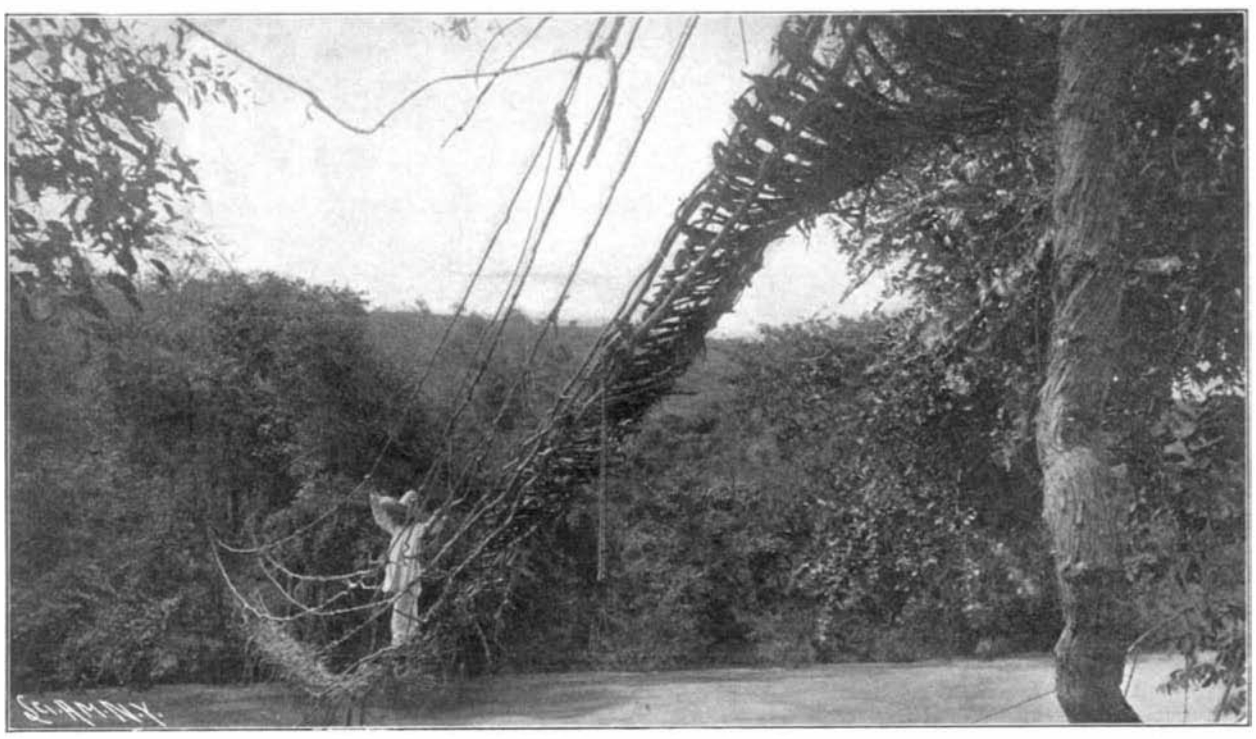
A NOVEL SUSPENSION BRIDGE.

BY CHARLES B. HAYWARD.

That "necessity is the mother of invention" is seldom better exemplified than in the case where man is confronted with an engineering problem with nothing but nature's tools—his hands—to solve it. Great praise has been forthcoming for the genius whose brain evolved the plans of such a bridge as the New York and Brooklyn suspension bridge; but would that same skill, which, aided by every facility possible, has produced such massive and well-sustained monuments of stone and steel, be equal to the emergency if confronted by the same problem, though on a diminutive scale, a thousand miles from a machine shop and possibly a hundred from a hammer and nails?

This, however, is the position of the natives in many parts of Mexico and Central America, where fairly wide and rapid-running streams are so numerous that even in some of the miniature republics above the isthmus their water power in the aggregate might compare favorably with that of Niagara. They are never dry and seldom fordable; when swollen by unusual rains they are often absolutely impassable for weeks except by a lofty bridge, and this the native has provided alone and unaided.

The tropical forest supplies lianas of every imaginable length and diameter, from the quarter-inch tendril to the vine with the girth of a man, and all, barring flexibility, with practically the same properties as steel cables. These, with a little rope and the boarding required for the footwalk, which is also supplied by the trees at hand, are all that are required. Work is begun without any controversy as to eyebars or suspension cables, and within a month, more or less—for there is never any hurry—the completed suspension bridge will be gently swinging in the breeze, unique in its freedom from iron or metal fastenings of any nature. A glance at the one shown in the accompanying illustration reveals the fact that, with the exception of anchorages, which are entirely lacking, all the principles of the suspension bridge as known to modern practice are in evidence. Stout trees are utilized as towers and form the bridge's sole support. The work throughout is done in the crudest manner, and as a rule one must mount several feet into a tree in order to begin the journey. To the uninitiated a trip across one of these bridges is not always an unalloyed pleasure, for it sways uncomfortably, sinks with any weight to a rather alarming degree, and the creaking and groaning of its members are far from reassuring. Nevertheless, they are built to last and are not temporary in any sense, occasional repairs being sufficient to maintain them for years. Needless to add, the capacity of one of these bridges is limited to man and his burden; a four-legged animal would have a difficult time crossing.



A NOVEL SUSPENSION BRIDGE.

EXHIBITS IN THE BOILER HOUSE AND THE PALACE OF MACHINERY, ST. LOUIS.

BY THE SPECIAL CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

The purpose of the collection of exhibits in the Palace of Machinery and in the Boiler House, officially known as the Steam, Gas, and Fuel Building, is to show, first, the modern methods for developing and using power, and secondly, the machinery and apparatus used in making machines.

The Power House and Machinery Building, in spite of the serious omission of several large European gas engines and producers that were contracted for but failed to materialize, is a most interesting field of study. The total fuel consumption averages somewhat over 400 tons per day. To insure that the requisite amount of fuel should be on hand, the Commissioner purchased 170 fifty-ton coal cars, which bring the coal direct from the mine to the power house. In order to provide against mishap, a large number of loaded cars are maintained at all times on the sidings, so as to insure that there shall be several days' supply of fuel on hand.

It is a significant fact that the whole of the boiler installation is of the water-tube type. First we have sixteen Babcock & Wilcox boilers of 400 horse-power each. Then follow the eight Heine boilers, which are also of 400 horse-power. Aultman & Taylor are represented by sixteen boilers, eight of them of 500 horse-power, and eight of them of 400 horse-power. Durr is represented by a 700-horse-power boiler that can carry 1,200 horse-power; Niclausse is represented by two 800 horse-power boilers that can carry 1,000 horse-power; Belleville has three boilers of 500 horse-power; Clonbrock one 300-horse-power unit of the marine type and one 250-horse-power stationary boiler. The most modern boiler in the whole installation is a Schuette boiler of 500 horse-power, manufactured at Stettin. In addition to the boilers themselves there is, of course, all the concomitant plant in the way of blowers, pumps, etc., that is necessary for the running of the plant. Some of these, however, have received separate treatment in this journal and need not be enumerated at the present writing.

To the second object aimed at by the Commissioners in charge of the Machinery Building, namely, the exhibition of machinery and apparatus used in making machines, about two-thirds of Machinery Hall is devoted. With a few exceptions the exhibits to accomplish similar results are found grouped in and about certain well-defined locations. Thus, means for guiding and controlling the flow of water, steam, and gas are located along or near the northerly wall of the building. Next, and toward the south, are machines for cutting and forming metals; the range of this assortment extending from the huge machines used in ship, engine, and car works, down to the pigmy tools used in watch making. Instruments which will measure to one ten-thousandth part of an inch and tools which do work so accurate as to require such refinement in measuring are here exhibited.

Toward the center of the building, power punches, presses, metal-bending and shaping tools, and forge shop requirements are grouped. Adjacent to these on one side is a fine display of abrasives and machinery for using abrasives. Next on the opposite side are pumps, air compressors and water meters. Beyond these are the gas and gasoline engines, a display which is good as far as it goes, but for reasons above stated gives an altogether inadequate idea of the remarkable development of the art as reached in Europe. To the east of the gas engine department is a collection of belts, pulleys, hangers, and shafting; and then follow hoisting engines, winches, and other apparatus and appliances for lifting heavy bodies. In succession follow pneumatic tools and appliances, fire hose and fire escapes and miscellaneous machinery, until the very interesting woodworking group is reached in the southeast quarter of the building, where several machines may be witnessed in operation.

Within the scope of the present article it is impossible to give any detailed account of the numerous exhibits; that has been and will be done in various illustrated articles in this journal. In the present connection we show a series of views taken in both the Boiler House and the Machinery Building. The Westinghouse Company exhibit a Parsons turbine direct-connected to a 400-kilowatt generator. Though it is a comparatively small turbine compared with the powerful units that this company is building for power station service, it is thoroughly typical of this very interesting development in prime movers. The turbine is running at a speed of 3,600 revolutions per minute and delivers a three-phase, 60-cycle current at a potential of 440 volts.

The fine engine built by the Elsaessische Maschinenbau A.-G. and the 700-kilowatt generator to which it is direct-connected, built at Belfort by the Société Alsacienne de Constructions, deserve all the favorable comment that they are eliciting. The engine is of 1,000 horse-power. Steam is admitted by transverse piston valves, carried above the cylinders, one at each end. These are operated by eccentrics, one eccentric serving to operate both the steam admission and the exhaust. The alternating, three-phase generator has a capacity of 700 kilowatts, and a voltage of 2,300.

Another exhibit that we illustrate is a Weber suction gas producer. It consists of a two-cylinder, upright 125-horse-power engine, direct-connected to a 75-kilowatt generator. The unit also comprises a producer, a scrubber and a receiver. It is entirely automatic, the feed of fuel being regulated according to the requirements of the producer; and the whole plant running with great regularity.

The group of fourteen Worthington fire pumps supplies the whole fire service of the exhibition grounds. The steam cylinders are 18 inches, the water cylinders 10 inches in diameter, and the common stroke is 12 inches. The battery of Cahall watertube boilers is exhibited by the Aultman & Taylor Company, who have contributed sixteen boilers of 400 and 500 horse-power to the boiler house plant. The Willans central-valve, high-speed engine is represented by a 1,000 horse-power unit which is running at 277 revolutions per minute. It is direct-connected to a 600-kilowatt Stanley generator. The engine is of the single-acting type, and runs under a working pressure of 175 pounds to the square inch.

The veneer-cutting machine shown carries the log between centers on which it rotates, and the veneer is cut by a knife held in a horizontal rest—in other words, the veneer sheet is "turned" off the log, and is nothing more nor less than a mammoth shaving several feet in width and length.

One of the "big" things in the Machinery Building is a huge 20-foot boring and turning mill that weighs no less than 375,000 pounds. The central boring bar and gear are carried on two massive columns. The machine is driven by Bullock motors, that for the main drive being of 80 horse-power and that for elevating the cross-rail of 10 horse-power. The Niles Company do not share the rather prevalent prejudice against any but a positive drive; for this great machine is driven by the friction feed shown in the foreground of the illustration.