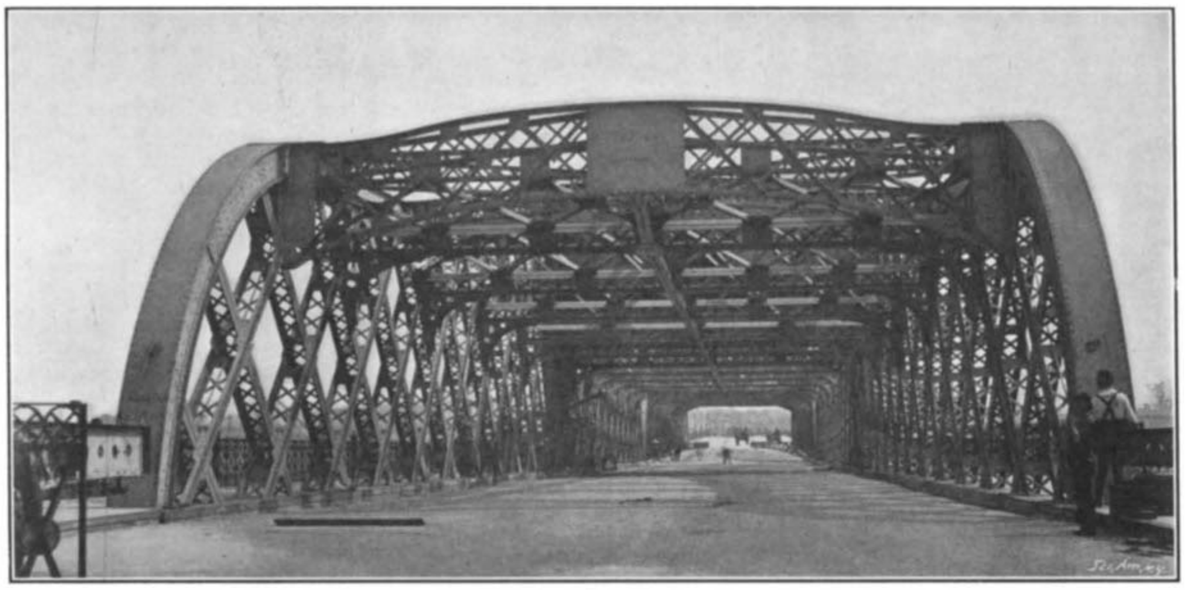
larged to the required dimensions, and, judging from the results already achieved, when the gun gave its 575-pound shell a velocity of 2,503 feet per second, it is fully expected that the desired velocity of 2,800 feet per second will be obtained. The piece will then equal in velocity the navy 10-inch gun; but, as the shell fired from the Brown gun is 75 pounds heavier than the navy shell, and of the two guns the Brown is 7.4 tons lighter, the resultant muzzle energy and the foot tons of muzzle energy per ton weight of gun will be considerably greater, as is evident from the table below:

	Length in Feet.	Weight in Tons.	Weight of Shell in Pounds.	Muzzle Energy in Foot Tons.	Foot Tons of Energy per Ton Weight of Gun.
Brown Segmental Wire-Tube Gun.............	37½	26.0	575	31,298	1,204
Navy Gun.................	37½	33.4	500	27,216	815

The above table tells its own story, and to anyone who has followed the development of modern ordnance and is familiar with the best that has been done, it will be seen that the development of 1,204 foot tons of energy per ton weight of gun has never been approached, the nearest to it being that of the Krupp 50-caliber 12-inch gun which develops 946 foot tons per ton weight of gun.

Since the design of the first 5-inch gun was brought out, Mr. Brown has developed an important improvement by substituting for the straight segments as used in that gun a series of overlaid curved steel plates, as shown in our illustrations. The plates are formed from sheet steel, varying in thickness from 1.7 to 0.4 inches, which is cut to the desired taper, and rolled in a special mill to the involute form shown in one of the accompanying illustrations. The substitution of these involutes for the longitudinal segments is a logical step along the line of development which is being carried out so successfully in this gun. The substitution of straight segments for the inner tube of the accepted type of gun was made, as we have seen, with a view to securing more thorough working and higher quality in the steel. The thinness of the curved sheets, and the thorough working and subsequent inspection to which they are subjected, insure a yet more perfect condition of the core.



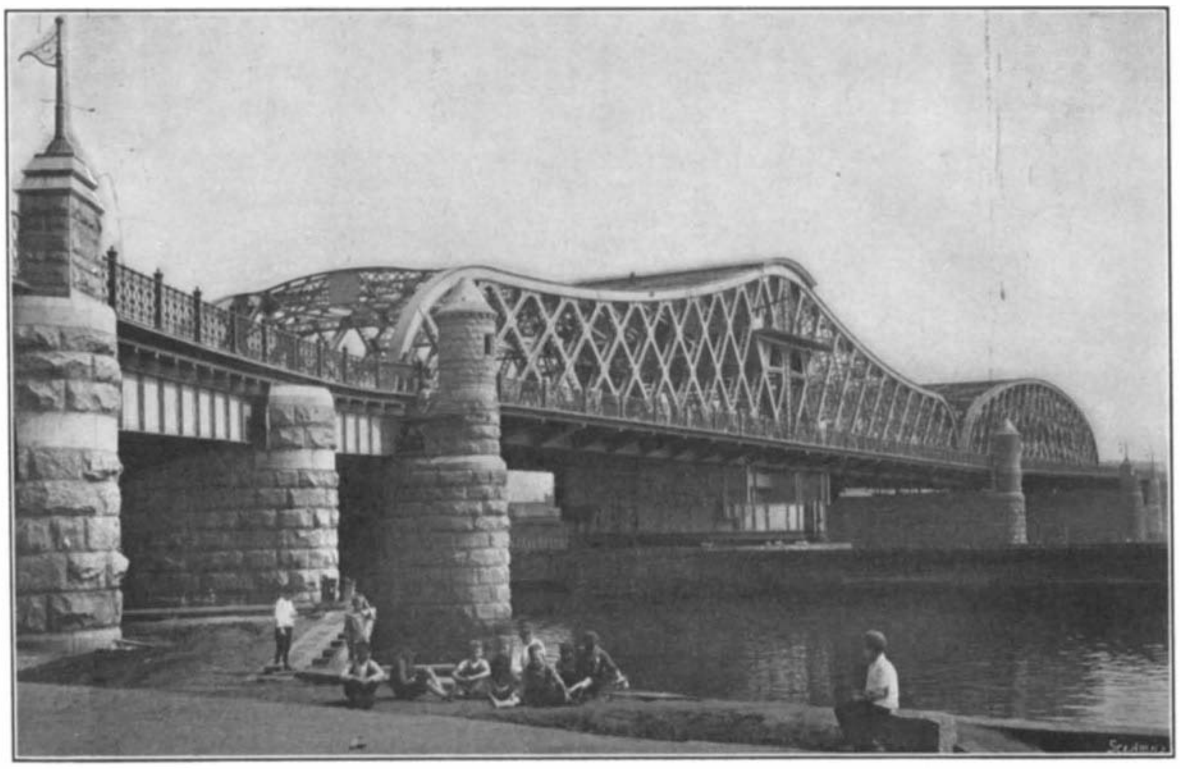
LOOKING NORTH THROUGH THE SWING-SPAN OF THE NEW BRIDGE.

Clear width of roadway, 42 feet.

The following description of the process of manufacture applies to a 5-inch gun which was built as a type piece and subjected to trials at Sandy Hook. The report of these firing trials, as made by the officer in charge, certainly does not betray any partiality for the gun, and therefore, particular value attaches to the fact that the results of the trials, as gathered from the report, prove that the gun has not merely achieved, but has considerably exceeded, the contract requirements. Unfortunately, it was mounted upon a carriage designed for guns of far less power, and it was impossible to carry the velocity to as high a figure as the gun was capable of securing, owing to the risk of injuring the carriage. The insufficiency of the carriage was foreseen and inevitable, and it in no way reflects upon the capabilities of the piece. In the construction of the segmental core, sheets of steel one-seventh of an inch thick, 30 inches wide and 19 feet long are cut into two pieces along a diagonal line, the resulting halves being each 24 inches wide on one end, 6 inches on the other, and 19 feet in length. One edge of the plates is planed to a curved bevel fitting the curvature of the outside of the lining tube, and each piece is bent in special rollers to the involute form shown in the accompanying illustration. Eighteen of these curved plates are superimposed on each other and assembled into the annular circular form shown in the illustration. They then are fastened by screw-bolts to two rings, one at the breech, and the other at the muzzle. Then more clamps are applied to the assembled segments, and a tapered lining-tube, rough-bored to 4 inches internal diameter, is forced by hydraulic pressure into the segments. More clamps are then added, one at every 4 inches of length. The lining-tube is then pressed home to its final position under a hydraulic pressure of about 50,000 tons. The structure is placed in a lathe and the outside of the segments is turned to a cylinder stepped with shallow shoulders at eight different points. The structure is then placed in another lathe, fitted with a gear for winding on the wire at a specified tension of 2,600 pounds per wire, or about 128,000 pounds per square inch. The end of the first wire is fastened by a plug into a hole in the first shoulder and is wound from there to the breech and back again to the shoulder, where it is fastened by plugging. The same process is repeated at each shoulder, the winding being carried to the breech ring and back to the shoulder from which it started. After the desired number of windings have been put on, the chase jacket is forced on with hydraulic pressure and a threaded muzzle cap is screwed into place. The trunnion jacket is then shrunk on, the liner is bored and rifled, and the breech mechanism fitted, leaving the gun ready for mounting.

We have before us a report by Prof. J. B. Denton, of Stevens Institute of Technology, of a mathematical analysis of the stresses of the 5-inch gun. From the summarized conclusions we quote the following:

"I. By means of the tension due to the wire windings all parts of the segmental core or tube will be bound together with sufficient pressure to cause the frictional adhesion between its curved lines of division to exceed the shearing forces which would be transmitted along these lines in a forged tube of the same thickness, when fired with powder developing the highest current pressures.



THE NEW WILLIS AVENUE BRIDGE OVER THE HARLEM RIVER.

Swing-span, 310 feet; fixed span, 250 feet; total length, including approaches, 2,507 feet.

"II. The metal of the segmental core, by virtue of the magnitude of its frictional adhesion, is as available as a source of longitudinal strength and transverse stiffness as the same thickness of solid steel.

"III. The division of the core into parts gives it an advantage over the same thickness of solid metal, in that a crack or incipient rupture at any point will not depreciate its usefulness; whereas a flaw in the solid metal may induce rupture.

"IV. The distribution of the wire windings secures a practically uniform compressive resistance in the firing tube, throughout its length, and without exceeding 90 per cent of the elastic strength of the tightest wire, the lining tube was probably compressed so that, with 50,000 pounds per square inch of powder pressure, it was not required to exert a tensile resistance."

With this testimony of Prof. Denton to the longitudinal and tangential strength of the assembled "segmental core" before us, it is interesting to note that the cost of the segmental tube would be materially reduced. Moreover, to the above undoubted advantages is to be added another of scarcely less importance, namely, that whereas the manufacture of hooped guns can be carried out at only four establishments in this country, the manufacture of this type of gun is so simple that it could be carried on in any machine-shop where there is a crane to handle it and a lathe of sufficient length to turn it; which means that there are at least a half-hundred shops in the United States that could safely contract for the construction of a number of these weapons.

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THE WILLIS AVENUE BRIDGE OVER THE HARLEM RIVER.

The opening of the handsome bridge which has just been completed across the Harlem River at Willis Avenue forms another important link between Manhattan Island and the suburban districts to the north of it. The new structure was commenced about three years ago, but its completion has been delayed beyond the time originally intended.

Although the length of the river-crossing is inconsiderable compared with the great structures which are being built across the East River, the overall length of the Willis Avenue Bridge entitles it to rank among the notable city bridges of the world. Its total length overall is 2,507 feet, and its total width overall, from railing to railing of the sidewalks, is 70 feet; while 6,200 tons of steel was used in its construction.

Commencing at the southern entrance at 125th Street, the bridge consists first of a masonry approach 345 feet in length. This is followed by 259 feet of short, plate-girder spans, carried on masonry piers, the last of these spans resting upon the fixed pier of the central swing-span. The latter is 310 feet in length between end pins, and provides two clear channel openings each of 108 feet width. To the north of the swing-span is a bowstring truss, 250 feet in length between end pins. To the north of this truss are six plate-girder spans, of a total length of 113 feet, followed by nine similar spans covering a length of 479 feet. The street grade is finally reached by means of a 200-foot masonry approach.

The most notable feature of the bridge is the swing-span and the adjacent bowstring truss. Both are constructed on the riveted system, the top and bottom chords consisting of built-up box sections, the web members being built-up latticed struts and ties. The swing-span is similar in contour to the swing-span of the Third Avenue Bridge over the same river, which was opened a few years ago. An endeavor has been made to secure gracefulness of out-line by substituting curved lines for the straight lines with which we are familiar in the typical pin-connected truss-bridge, and the attempt has certainly been successful. The draw-span measures 46 feet from center to center of the trusses, which are 48 feet in depth between the centers of the chords at the deepest part of the truss over the center pier.

A clear roadway of 42 feet is provided, and the effect, as seen in the accompanying photograph, is certainly spacious and imposing. The sidewalks are 9 feet in width. They are carried on cantilever trusses which are riveted to, and extend at right angles from, the bottom chords of the trusses. The floor of the bridge consists of transverse floor beams which extend from truss to truss, with longitudinal stringers riveted between them, the whole being covered over with buckle-plates on which is laid a concrete and asphalt roadway.

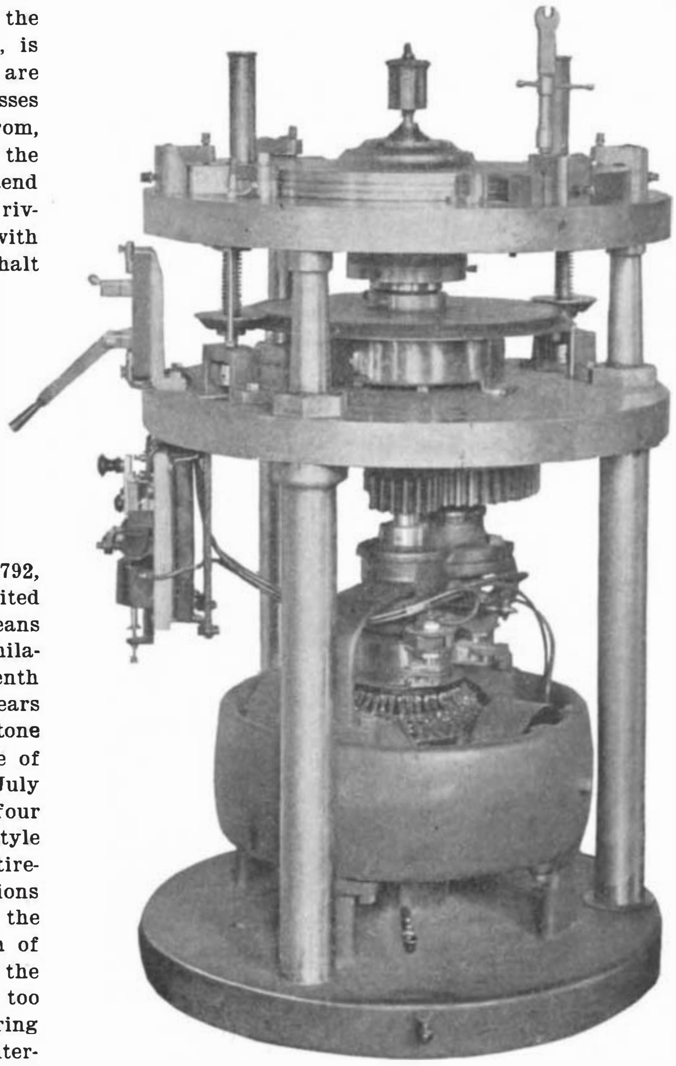
The extensive sub-aqueous foundations called for 33,600 cubic yards of concrete and masonry below the water-line, and in the piers and abutments, above water, there are 23,800 cubic yards of masonry. The total cost of the structure was $1,500,000.

HOW MONEY IS MADE.[*]

BY MARCUS BENJAMIN, PH.D.

The Mint in Philadelphia was established in 1792, and is the parent institution of its kind in the United States, the other coining mints being in New Orleans and San Francisco. The first mint building in Philadelphia was erected on the east side of Seventh Street above Market Street, but before many years it was found too small for use, and the cornerstone of the second edifice, which is on the north side of Chestnut Street below Broad Street, was laid on July 4, 1829, but it was not ready for occupancy until four years later. It is of marble and in the Grecian style of architecture. In 1854 the building was made entirely fireproof, and since then numerous alterations have been made in the interior to comply with the requirements of the times. But with the growth of the country and the increasing demands upon the mint for coinage, the building has again grown too small, and a new mint has been erected on Spring Garden Street, near Seventeenth Street. Many interesting memories are associated with the old structure, and it would be pleasant to recall the work of the distinguished men who have been connected with it, such as James C. Booth, the melter and refiner, who was succeeded by D. K. Tuttle; Jacob B. Eckfeldt, assayer, and William Barber, engraver, who was succeeded by Charles E. Barber. Of these Messrs. Barber and Tuttle are still in the service. There is only space to mention one among the interesting rules, which required that provision should be made "for the care and feeding of watch-dogs," but it illustrates the primitive methods by which the Mint was cared for in early times.

The process by which the ore from the mine is changed into the new and glittering coin is long and tedious, but a brief summary of the principal steps may be of some interest. The ore as it comes from the ground must first pass through the smelting process, by means of which the metal is extracted and converted into bars of gold or silver, the methods naturally varying, according to the character of the ore and the locality.



UPSETTING MACHINE—USUALLY CALLED A "MILLING" MACHINE.

THE NEW MINT, SPRING GARDEN STREET, PHILADELPHIA.

Some idea of the enormous amounts that have been handled by the various mints and assay offices is shown by the statement that $2,996,763,252.27 represents the total amount of coinage of the various mints of the United States from the establishment of the Philadelphia Mint to the end of June, 1900. Of this great amount the total gold coinage was $2,167,088,113, the total silver, $796,171,159.55, and the total minor coinage amounted to $33,503,969.72. The bars of gold or silver, known as "bullion," are carefully assayed, either at the Mint or at one of the assay offices in New York city, Helena, Mont., or Denver, Colo.,[†] and from these the coins are made. The first step consists in preparing an alloy for coinage of the refined gold or silver, which is nearly pure, with copper, and this is accomplished by weighing out quantities of gold and copper, or silver and copper, which are then melted together in a large black-lead crucible; and after the molten metals are thoroughly mixed they are poured into cast-iron molds to produce rectangular bars called "ingots," which vary in size according to the denomination of the coin for which they are intended. Thus, the ingot for the "double eagle" is 12⅝ inches long, ½ inch thick, and 1½ inches wide, and weighs 80 ounces, while the ingot for the silver dollar is 12½ inches long, ½ inch thick, and 1⅝ inches wide. The ingot is then passed between heavy rolls from which it issues in long narrow strips. This operation is called "breaking down," and makes the metal hard and springy, and if continued would cause it to crack and split. In order to prevent this the strips are annealed by being heated in a furnace to about 1,500 deg. F., where they remain for about an hour and a half, according to the heat of the furnace and the size of the strips. They are then cooled in water and each strip wiped dry, after which they are finally passed through the rolls. "Double eagles" and "eagles" pass through the finishing rolls three times, while "half" and "quarter eagles" must go through at least four times. The strips are again annealed, cut in two for convenience in handling, taken to the pointing rolls so that an inch and a half of the end may be pointed or flattened, and greased with tallow to permit their easy passage through the dies of the drawbench. The drawbench consists of two independent sections, each of which has two dies regulated by set-screws, and between these dies the pointed end of the strip is passed, being seized by the jaws of the carriage, drawn by means of an endless chain, which reduces the strip as nearly as possible to standard weight. This is ascertained by weighing sample blanks or planchets that are cut from either end. When the strips are deemed of proper weight they are taken to the cutting shears and the pointed ends cut off, after which they pass to the cutting press, where, by means of a steel punch working into a matrix, the planchets are cut therefrom. These blanks are then taken to the washing-room, where they are cleansed from grease by washing in a lye composed of soap, borax, and water. After rinsing in clean water they are dried in a large copper pan heated by steam. They are then carefully examined on the selecting table and all perfect blanks separated from the imperfect ones, and, in the case of gold coins, must have the following weights: "Double eagle," 516 grains; "eagle," 258 grains; "half eagle," 129 grains; and "quarter eagle," 64.5 grains, although an allowance of half a grain is permitted in the case of the "double eagle" and "eagle," and a quarter grain in the "half" and "quarter eagle." This weight is determined in the adjusting room, where each piece is placed upon the balance, and, if heavier than the limit, is reduced by filing its edge, whereas if lighter it is condemned and returned to the melter. The accepted planchets are then taken to the milling machine where the raised edge, technically called "milling," is put on them.

The machines known as milling machines are simply upsetting devices, and the former designation often misleads one not familiar with minting processes. We illustrate the latest type, which has just been installed. Its duty is to upset the blank after it leaves the cutting press by passing the piece between a segment and a revolving disk, shown at the extreme upper left-hand corner, just below the feed tube. Grooves are cut in the disk and segment by a sharp tool, and the shape of the grooves has been the subject of considerable experiment in order to give as square an edge as possible to the finished coin without producing a fin. It is driven by a 3 horse power compound-wound motor running at 375 revolutions per minute, and transmits a rotary movement to the disk through back-gears. The disk runs at 60 revolutions per minute. The blanks are fed by the operator into the tube and are pushed against the disk by a small feeder, and the friction on the disk carries the blank around the inside of the segment and then it drops into a box. This upsetting machine will upset 575 half-dollars per minute, and the machines for other denominations will turn out a proportional amount. Nine of these machines, excepting the motor, were designed and built at the U. S. Mint, and it is the intention of the authorities to gradually work into the designing and building of several special machines for coining operations.

The advantage of the milling process is that it protects the surface of the coin from abrasion. The milled pieces must be again cleaned and softened, which is accomplished by annealing them at a cherry-red heat, after which they are dipped into a solution of sulphuric acid and water sufficiently strong to clean and brighten them. They are then rinsed in boiling water and shaken in sawdust to dry them, after which they are ready for the stamping press. Before stamping a brief description of the die is necessary. The design being selected, a drawing is made the exact size of the coin required, and from this drawing a tracing is taken for the purpose of transferring the design to the die. This is accomplished by covering the surface of the die, which has previously been made smooth, with a thin coating of transfer-wax; on this wax the tracing is reproduced by rubbing, leaving the design on the steel, and as this is easily obliterated it is best to go over the lines with a sharp-pointed instrument. The next step is to remove the steel in the die by means of chisels and gravers, so that a relief may be had on the coin. From time to time, as the work progresses, proof impressions are taken until the desired result is obtained. The die is then hardened, after which it is ready for use in the press. These dies are then adjusted in the stamping presses and the blanks fed to

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[*] For the information contained in this article the writer is greatly indebted to the courtesy of the Hon. George E. Roberts, Director of the Mint.

[†] The assaying process is briefly described in an article by the present writer on "The Methods Employed by the Assay Commission" that appeared in the Scientific American for May 19, 1900.