slightly overlapping each other and so hinged or hung on gudgeons as to hold the wind from one side and fly open when blown upon from the other. Thus the resistance of the idle vane to the wind was but a very small fraction of the power developed, as only the edges of the slats were presented. A model of his wheel was erected on the roof of his residence at 15 Great Windmill Street, London, and he figured that with four vanes each twelve feet square it would be capable of developing nine horse-power. He also prepared a table of wind velocity and resistances.

American wheels were largely introduced throughout Germany as a result of the Centennial Exhibition of 1876, and quite a business was done in this class of machinery until the German manufacturer realized that he could build the same thing to greater advantage, and there are at present upward of half a dozen large concerns in the Empire devoted to the construction of windwheels, each operating under a system and patents of its own. The portable windwheel and pump seem to be a feature of this class of power peculiar to Germany, and are used for irrigating, draining, and general agricultural purposes.

Numerous of the smaller towns throughout Germany utilize wind power almost exclusively for their municipal waterworks and in a few instances for public lighting, both of these applications having proved an unqualified success. Needless to add, the utilization of wind power on such an ambitious scale is practically unthought of here. The town of Emden is a good instance of the former, an 18-horse-power, 40-foot wheel being used at its pumping station at Tergast. It is of the slat-vane type familiar in this country, but in place of the usual rudder is equipped with two auxiliary windwheels, as is the case with all high-powered German wheels. These wheels are set at right angles to the main wheel on the end of a bridge-like construction, and are connected to the tower by means of shafts and gearing. Their motion causes the whole upper work to revolve about the tower, thus always maintaining the wheel face to the wind. This feature is a radical departure from American practice which immediately strikes the reader, and may be accounted for by the fact that such powerful wheels have never been employed here in any capacity. The wheel under consideration is coupled to a compound vertical pump having a capacity of 5,500 to 6,600 gallons per hour, according to speed. Its remarkable efficiency is evidenced by the fact that it delivers the water at this rate to a reservoir eight miles distant and 134 feet high. Two 10-horse-power petroleum motors are used as a reserve.

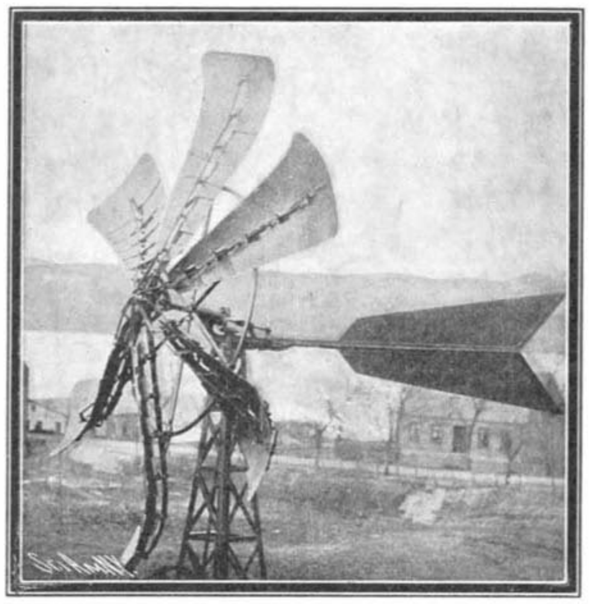
One of the principal German builders, located at Kiel, has for some years past been developing the "Soerensen" system, for which patents have been granted to a Dane of that name. Apparently the principle that has been proceeded on ever since windwheels have been in use is "the larger the surface, the greater the power," but the investigations of Prof. P. La Cour proved the fallacy of this reasoning. Later on Soerensen invented his "conical wind motor" and placed one at the disposal of Prof. La Cour for experimental purposes. The "Ventrokat" and "Windrose," types of German wheels of the highest efficiency, were tested together with a Soerensen wheel, all being of the same diameter, and showed the following results:

	Ventrokat	Windrose	Soerensen
Surface in centimeters.	7,440	2,976	1,188
Power in kilogramme-seconds	1.59	1.77	2.34

Thus the Soerensen motor developed 50 per cent more power than the Ventrokat with a surface of one-seventh the area, and 33 1-3 per cent more than the Windrose with its 2.8 times greater area, and 29 per cent more power than an earlier type of Soerensen motor which had but 7 per cent less surface.

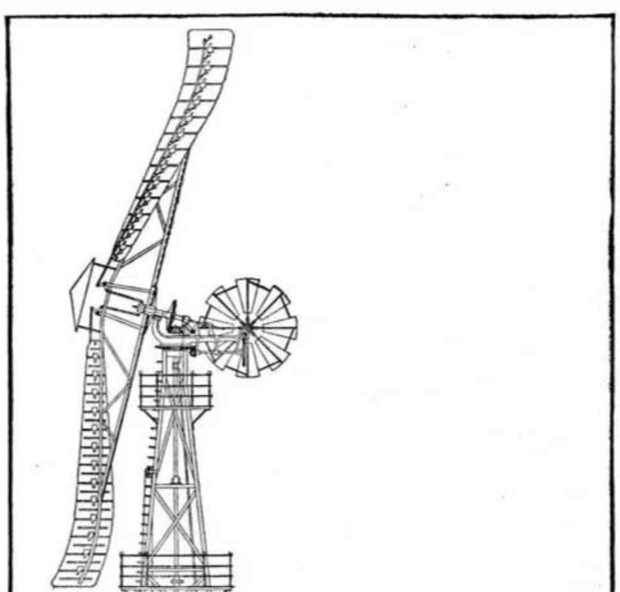
The extraordinary superiority of this motor over existing types is due in great part to the form of its vanes, particularly at their ends, where the greatest wind pressure is exerted, but the unusual distance between the vanes adds an element of power, the importance of which has hitherto been totally overlooked. This space not only permits of the passage of the wind between the arms so that the latter meet with greatly decreased resistance in revolving, but a vacuum is seemingly created, and this with the absence of back pressure accelerates the motion of the wheel.

Some of the illustrations show a 6-horse-power wheel for pumping, mounted on a barn roof, and a 9½ and a 15 horse-power wheel respectively, the latter supplying power for quite extensive milling plants. The huge tower wheel shown was designed and built especially for electric lighting. With the wind at 7 meters (or approximately 23 feet) per second it develops 50 horse-power and is without doubt the largest wheel ever built for any purpose. Naturally the most difficult problem to be overcome in adapting the windwheel to electric lighting is the matter of speed regulation, but this has been very successfully solved by means of various regulators, prominent among these being the Rontescher "Tourenregler." By reason of the high first cost and expense of maintenance of a battery of accumulators of sufficient capacity to relieve the generator of the above wheel during periods of calm, it has been found much more economical to install gasoline engines as a reserve. How infrequently the latter are needed is evident from the fact that during the two or more years this set has been in use, there have scarcely been thirty days per annum in which the wind failed.



A 4-Horse-Power Wheel for General Farm Work.

In this connection it is interesting to note that a plant of the above type using gasoline power as a substitute and representing a total investment of 18,000 marks has earned a net dividend of 12 per cent on the capital, while the same plant with gasoline power alone installed at a cost of 11,000 marks falls far below this. As already referred to, a public electric lighting service depending upon wind power is successfully maintained in a Danish village, so there is no reason why isolated farms cannot accomplish all the power work necessary by means of electric current generated by a windwheel. For periods of calm horses may be substituted. It is further the practice to equip such plants with two dynamos, one much smaller to be used with a moderate wind, both being run in very heavy winds.



Section Through a Wind-Power Plant.

GERMAN WINDMILL PRACTICE.

A 15 horse-power wheel of the Soerensen conical type is employed to run the machine shop at a small government dockyard in the town of Husum, Germany, and is very efficient. With a wind speed of exactly 4.4 meters, or 6.7 miles per hour, this wheel has driven a 12-foot engine lathe, a shaper, a blower for two forges, and a circular saw of 20 inches diameter, sawing a 7-inch oak log, all the machines being driven at the same time and at full speed.

MULTI-FIREARMS OF ANCIENT TIMES.

A very rare and curious specimen of an ancient repeating flint-lock pistol has lately come into the possession of Mr. Sumner Healey, of this city. The pistol, of which we produce a drawing and photograph, was made at the end of the seventeenth century by Wetschgi Augustus, who died in Vienna A. D. 1690. The pistol contains two magazines, one, A, which contains the powder, and the other, B, contains the balls, twenty-one in all. An additional priming magazine H is on the outside of the lock and close to the flash pan. To load, one depresses the muzzle and turns or rotates the cylinder C by means of its exterior lever. One of the balls contained in the magazine B drops into the cavity E, which comes opposite B. At the same time the powder chamber D of the cylinder is filled with powder from the magazine A. When continuing to rotate the cylinders, the ball contained in the cavity E falls into the funnel-shaped breech, and by a continued motion of the cylinder the cavity D is brought opposite the breech of the barrel, where it remains until the shot is fired. During this time the reduced prolongation of the cylinder at the exterior rotates and scoops from the magazine H a sufficient quantity of powder to prime the flash pan. A continued movement closes the flash pan cover G and brings the hammer to full cock. When the pistol is fired, the priming charge shown at E communicates the fire through the two small holes to the charge contained in the cylinder.

The weapon bears the following inscription: FECIT ET INVENTIT WETSCHGI AUGUSTAE.

It may be readily seen that unless the revolving cylinder is accurately fitted, the danger of using such a weapon must be great, the powder in the butt, sufficient for twenty-one charges, being separated from the barrel only by the revolving cylinder, which serves as a false breech for the barrel.

A weapon of like construction to the above is in the Musee d'Artillerie, Paris, and is catalogued as M1766, but very few of these weapons, either gun or pistol, are known to be in existence. Among others who built similar weapons are Jan Sander, of Hannover, and Antonio Constantin, of Ferrara, Italy.

From a military point of view, the design of the arm gives evidence of being far in advance of its time. If everything works properly, the arm can be fired nearly as quickly as a modern weapon of to-day. Very little time is required for charging, and it is only necessary to fill the compartments with bullets and powder through the orifice F, with no counting and measuring. The charges are automatically measured, and the load is fully as accurate as that of metallic cartridges.

Altogether, the design and workmanship of the pistol make it a most valuable and remarkable relic.

Another pistol in the same gentleman's collection is a four-shot flint-lock pistol (Fig. 7). The weapon is evidently of English origin, and was presumably manufactured about 1750. It has two separate hammers, two triggers, and two separate flash-pan covers. The two upper barrels are fired separately by pulling the respective triggers. When these are fired, to fire the lower barrels one turns the lever shown at the center of the pistol, which brings two fresh primings in contact with the sparks from the flints, and thus communicates the flame to the two lower barrels through an orifice which is opened by the turning of the lever.

The arm can be fired quickly. All that is necessary after the first two shots are fired is to reclose the flash pan covers and to recock the hammers.

Fig. 8 shows a two-barrel, English flint-lock pistol with spring bayonet attachment, made by Nock, the celebrated London gunsmith. The pistol works on the principle of that shown in Fig. 7, with the exception that it has two barrels and one hammer and flash-pan cover only.

Fig. 9 shows a United States flint-lock pistol, caliber 70, made for the United States government by Simeon North, Berlin, Conn., about 1813. No pistol made for the government in early days is so much sought for by collectors as this, known as "North's Berlin." On the lock plate, in the rear of the hammer is stamped "S. North, Berlin, Con." Between the hammer and the pan is an eagle and under the eagle is stamped "U. States."

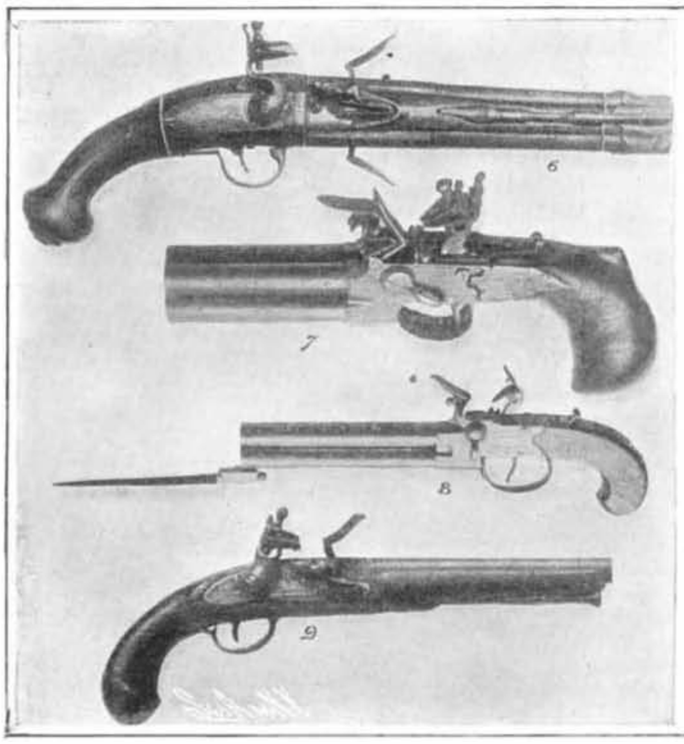
This particular model was only made one year, and but very few are known to be in existence.

Fig. 6 shows a two-barrel, revolving flint-lock pistol made by Bauduin, a French gunsmith, about the middle of the eighteenth century. This arm may readily be called the precursor of the modern revolver. The top barrel being fired, one revolves the barrels by hand, and as soon as the hammer is recocked, the pistol is ready for the second shot.

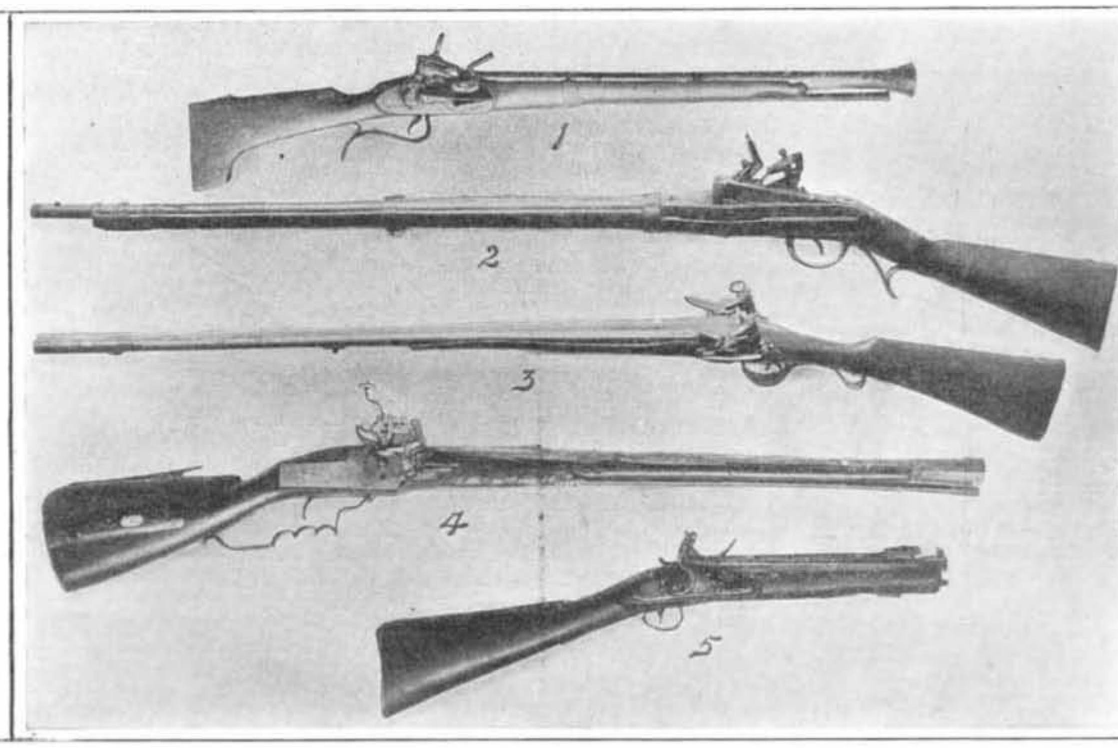
Among some guns in the same gentleman's collection, photographs of a few of which we reproduce, is that figured 1. which is an example of the early Spanish snap-hammer blunderbuss, made about 1700. Fig. 5 illustrates an English blunderbuss, manufactured by Twigg, of London, and shows the blunderbuss in its most perfected form. The arm, besides being a firearm, carries a folding bayonet on top of the barrel. Similar arms were much used in England in the latter part of the eighteenth century, most of the guards of the old English mail coaches carrying them in a special compartment at the rear of the coach. Fig. 2 shows John H. Hall's patent breech-loading flint-lock rifle. This arm is the first breech-loading weapon ever patented in the United States, and was patented by William Thornton and John H. Hall, May 21, 1811. In 1815 Mr. Hall first brought to the notice of the government the advisability of making all parts of a gun interchangeable with any other gun of the same model. In 1819 John H. Hall contracted with the United States government to manufacture a certain number of these breech-loading flint-lock rifles. The gun can well be described as the first successful breech-loading military arm, and also the first gun ever built on the interchangeable plan. Fig. 3 shows a Spanish double-barrel flint-lock gun of the beginning of the eighteenth century. While a few double-barreled guns were made some time prior to this in Italy by some Italian gunsmiths, the Spanish craftsmen were the first to forge a light, strong, and accurate-shooting double-barrel. In later years the double-barrel flint-lock gun was brought to its high state of perfection through the efforts of Joseph Manton and a number of other English gunsmiths. No. 4 illustrates a German rifled wheel-lock arquebus, made about 1620. It is believed that guns were first rifled by Gaspard Zollner, of Leipsic, about 1498; others say by Augustus Kotter, of Nuremberg, about 1500. In 1631 William, Landgraf of Hesse, had several companies armed with rifled carbines. The earliest authority we have for rifling in England is an English patent dated 1635.

The same gentleman has a number of United States flint-lock muskets dating from 1799, when the first musket was made for the United States government, to 1842, when the last of the flint-locks were made.

Altogether, the collection, although small, gives evidence of having been carefully and tastefully selected.

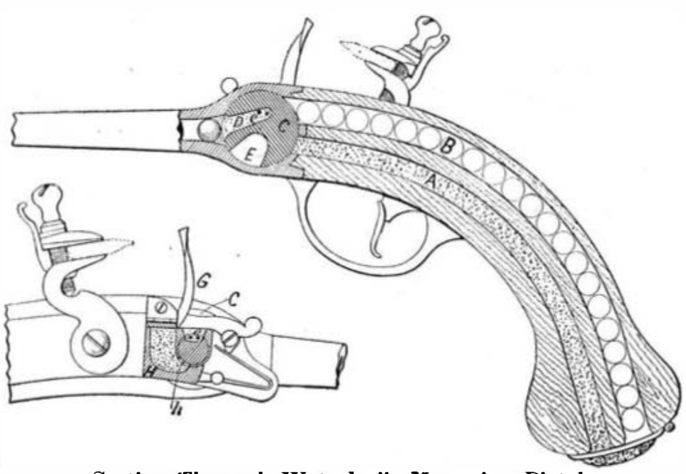


6. French two-barrel revolving flint-lock pistol made about 1750. 7. Four-shot English flint-lock pistol made about 1750. 8. Two-shot English flint-lock pistol with spring-bayonet attachment. 9. "North's Berlin" U. S. pistol made in 1813.



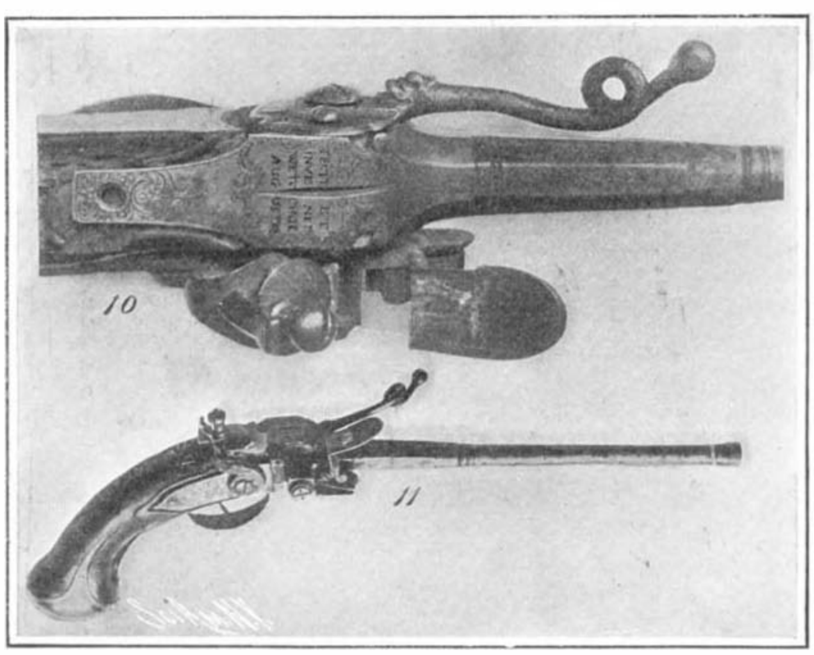
1. Spanish snap-hammer blunderbuss made about 1700. 2. First breech-loader ever made in the U. S. 3. Spanish double-barrel flint-lock gun made about 1700. 4. German rifled wheel-lock arquebus made about 1620. 5. The most perfect form of English blunderbuss. A folding bayonet is carried on top of the barrel.

Antique Pistols and Rifles.



Section Through Wetschgi's Magazine Pistol.

Made about beginning of eighteenth century.



Wetschgi's Pistol.

10. View of priming mechanism. 11. General view of pistol.

SOME REMARKABLE OLD PISTOLS AND RIFLES.

Prof. C. E. Reeves, of Benton Harbor, Mich., makes use of an ingenious application of the principle that the product of two parts is greatest when the parts are equal, to multiply numbers of two figures when their difference is not over twenty. By taking two numbers having the same sum as those whose product is required, one of which is a multiple of ten, you are able to find their product by using a multiplier with only one significant figure. This product will vary from the desired one by the product of parts of the difference of the more remote factors shown by the other pair of factors and will be that much too small if the new factors show the greater difference, or too large if the reverse be true.

To illustrate, let it be required to multiply 18 by 23. The nearest multiple of ten is 20, and 21 is the other new factor, giving a product of 420. The difference of 5 between 18 and 23 is divided by the 20 into two parts, 2 and 3, whose product, 6, must be taken from 420, giving 414, the product desired. In squaring numbers the rule becomes very simple. For example, to square 47 you multiply 50 by 44 and add the square of 3, which gives 2209. The rule seems well adapted for use by accountants, builders, and estimators where much multiplying is required.

An important water-power scheme has been authorized by the government of the Swiss canton of Schwyz. A barrage 78 feet high, 127 feet long at the base and 307 feet at the top, is to be built across the River Sibl. The result will be the formation of an extensive lake, with a superficial area of eight square miles near Einsiedeln. Existing roads through the valley are to be replaced by bridges, one of which will be 3,153 feet in length. An immense motive power will be derived from the water as it flows into Lake Zurich, 1,500 feet below.

Ives' New Process Replicas of Rowland Gratings.

Thorp's method of reproducing Rowland spectroscope gratings by making a celluloid cast and mounting it on glass has produced copies good enough for some purposes, but the celluloid film always distorts sufficiently to mar the definition more or less, so that even the best of them define better over some limited portion of their area than over all. They give the best results only when the rays entering the spectroscope are practically parallel, as with direct sunlight without a condenser, and transmitted through a selected limited portion of the grating. Even then, owing to some scattering of the light, which manifests itself as a pale fringe or halo about the lines in bright-line spectra, the lines of the solar spectrum do not appear as black as with the original Rowland grating. Even if the celluloid film did not stretch, the manner of putting it down on glass would cause the inevitable slight unevenness of thickness not only by refraction to destroy the perfect parallelism of the emerging rays, but would distort the plane of the diffracting surface, and the difference in refractive index of the celluloid and glass would produce disturbing reflections between the two surfaces of the replica. The defects introduced by any one of these sources of error may be slight, but that altogether they are of very material importance the result always shows.

By a remarkable improvement upon this method, made by F. E. Ives, replicas giving entirely satisfactory definition are now made, and so finished that they are no more easily injured than glass prisms.

This improvement is effected (1) by making the casts in a harder and less elastic material than celluloid, by (2) putting them face down upon the glass and forcing them into optical contact therewith, so that the perfect plane of the diffracting surface is preserved, and by (3) sealing them up under another plane glass, with a balsam mixture having the same refractive index as the casting material, so that the perfect parallelism of the transmitted ray is insured, and at the same time the grating is protected from injury.

The Good Old Times.

According to one of the old English chronicles, royalty, in 1234, had nothing for a bed but a sack of straw. Even in the days of Queen Elizabeth at least half of the population of London slept on boards. Blocks of wood served as pillows. The sleeping chamber of the Queen was daily strewn with fresh rushes. Carpets were unknown. Henry VI. immediately on arising tossed off a cup of wine. Tea, coffee, and chocolate were, of course, unheard of at that time. Sugar was to be had only in drug stores, and then by the ounce. These were the good old times.

Steel castings are manufactured with open-hearth furnaces and with small converters. Where castings of various sizes are made, as in a general steel foundry, a small open-hearth furnace affords excellent results, as it gives control over both the composition of the steel and the melting temperature.