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CASTING A STATUE OF HEROIC SIZE.

It would be a most difficult task to mention and separately describe each and every step which must be carefully noted by the operator in casting bronze in order that the resulting copy may be a facsimile of the original. Extended practice enables the founder to note all these features without necessarily appearing to devote more attention to one than to another; in a certain sense the work, from the melting of the metal to the final flowing, pursues a beaten path, along which are distributed certain guide marks, the absence or even the unusual appearance of any one of which quickly gives notice that all is not as it should be. It is here that we find a most apt illustration of the value of little things, since the most trivial neglect of a seemingly insignificant portion of the work may not only injure but destroy the casting.

Casting in bronze does not consist solely in simply taking a pattern, making a mould, and running in the metal; it is an art only to be acquired by long and patient toil, close study, and that most essential and spurring incentive, a fascination for the work. That success can only be achieved by this means will be understood by any one who will spend an hour in a bronze foundry, and note the time and care spent in making sure that one step is perfected before the next is even approached. There is no sign of the presence of that most pernicious habit, too frequently permitted in other callings, in which a distasteful part may be slurred or left half finished, and a rush made for something more agreeable. The bitter and sweet must receive the same attention, as both are equally dangerous when slighted.

One requisite qualification in the make-up of the bronze founder is an ability to obey orders. He receives from the sculptor a model in plaster which he is expected to reproduce in bronze; if he produces an exact counterpart, he has performed his whole duty, and has strictly abided by his orders, which may be concisely expressed as "follow copy." It does not come within his province to attempt to improve upon the pattern set before him, but to reproduce it, whether full of blemishes or perfect. The artist does not expect him to improve his work.

Bronze statues were made two and perhaps three thousand years ago, the earliest consisting of small plates hammered into the desired shape and fastened together by nails or rivets. After this they were cast solid and also with a core. At the present time it is the general custom to divide the statue, when of heroic size, into several sections, make a separate casting of each section, and then unite the parts by riveting; the joint so formed, owing to the increased thickness of the metal, being of greater strength than the adjoining parts. But a great step in advance was recently made by The Henry-Bonnard Bronze Company, of this city, when they succeeded in casting, practically in one piece, Mr. J. Q. A. Ward's statue of the New England Pilgrim. The accompanying engravings (we wish here to acknowledge the kind courtesy of the general superintendent of the works, Mr. E. F. Aucaigne, for facilities extended to us) represent the "Pilgrim" as completed, the mould made ready for the metal, and a view of the foundry showing the position of the flask at the casting of the statue of the late Col. Wadley, of Georgia. This work is of interest because of the great difficulty attending each step, because it is the first time so large a single piece was ever cast, and because of the complete success reached. The Pilgrim was cast entire, with the exception of the head and right arm.

It is apparent that a statue used as a pattern will not draw; and in order to form a mould from it, it must be treated in a way very different from that in vogue in iron and brass

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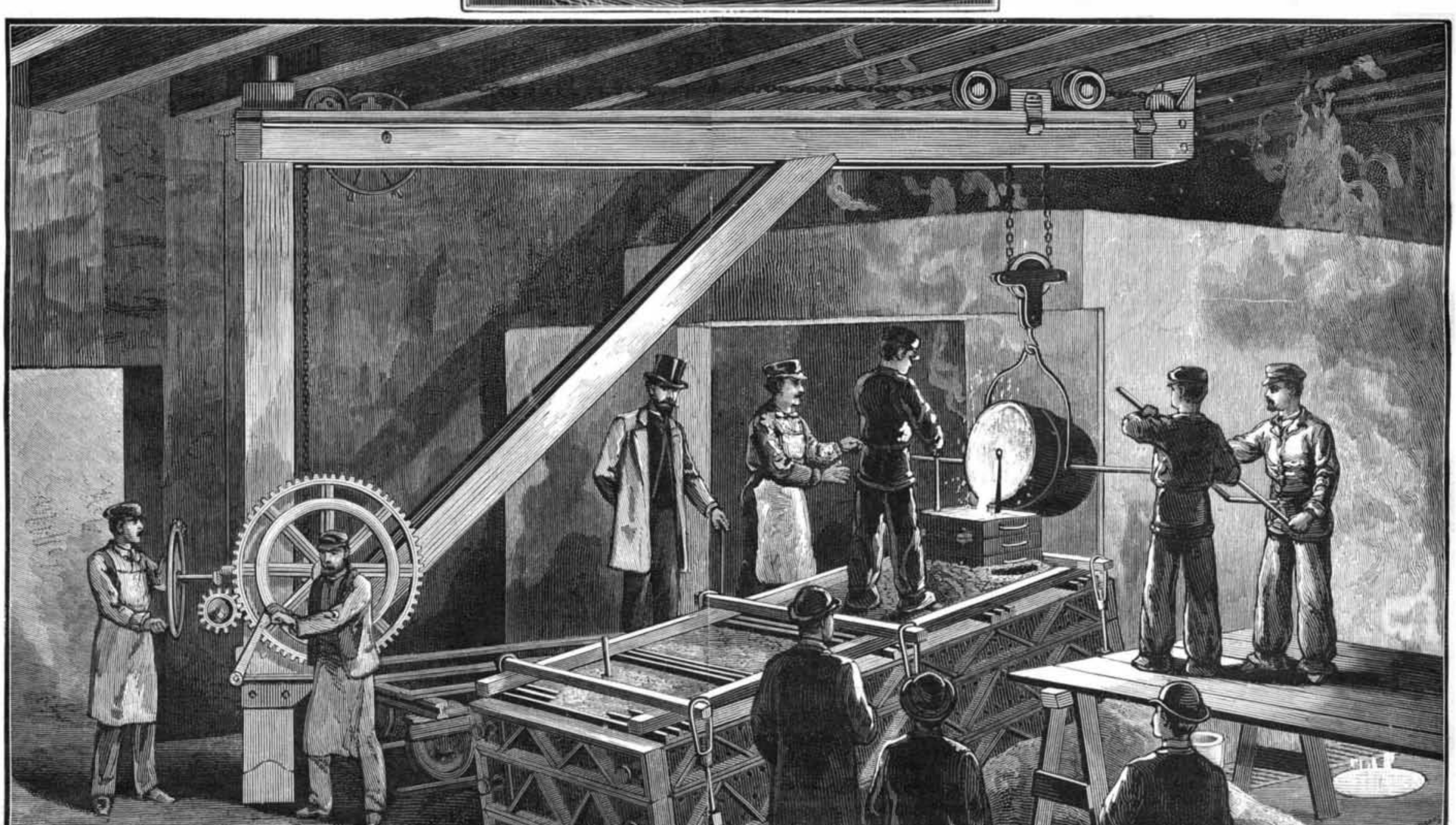

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founding. Yet this presents no obstacle to the bronze founder beyond now and then taxing his ingenuity. A piece mould is made of the plaster statue, the one we are about to describe consisting of more than 1,100 pieces. This piece mould is made of French sand, and is built up about three or four inches thick. When the statue has been completely covered, these pieces are separated and dried, and then reassembled, the space occupied by the statue being filled with sand to form the core. The pieces are again removed, and the core is pared down, the quantity of sand removed from the surface determining the thickness of the metal. The pieces are again assembled around this core, and then placed in the flask (shown in the large view), the space between the piece mould and sides of the flask being filled with sand packed tightly, when the metal is run in. Why there should be so many pieces in the mould will be readily perceived.

As an illustration, we may take the cavity in the ear, supposing it to be a conical opening with the base toward the interior. If we represent this opening by $\overset{3}{\underset{1\ 2}{\wedge}}$ we shall have a triangular cavity which it is necessary to fill with sand so disposed that it may be removed and yet be an exact imprint of the interior. The space marked 1 is first filled with a small trianglar piece of sand, and then the space marked 2. The adjoining faces of these pieces are so trimmed as to form a wedge-shaped opening, the base of which is toward the exterior. Since each piece within the cavity must pass freely through the opening marked 3, it may be necessary to fill the interior with many small pieces The sand forming each piece is thoroughly tamped as it is put in, to compact it, and make it retain its shape, and each completed piece is dusted, in order that its neighbor will not stick to it. Channels and indentations are formed in each piece, in order to insure their assuming the same relative positions whenever reunited. In this way all depressions in the mould are filled with small pieces varying in size from that of a pea up. When the statue has been completely covered, these pieces are removed and carefully dried. They are then reassembled, and the interior filled with sand packed tightly. They are again taken apart, to allow the core to be trimmed down. To distribute 1,100 small and large pieces of sand, and remember where each piece belongs—for in putting them together there must be no squeezing to force a fit—is a task of no small magnitude.

The exterior of the core is removed, the thickness of the layer taken away representing the thickness of the metal in the statue. The mould is then built up around the core, which, in the case of the Pilgrim, was supported at the feet, the neck, and at the right shoulder. This formed a narrow space between the core and mould to receive the metal. The space separating the core and mould is as thin as it can possibly be made and yet insure a complete distribution of the metal. The main object to be accomplished by this is to effect a rapid cooling, in order to hasten the setting of the metal, to prevent a separation of the tin and copper, this being likely to occur, owing to the wide difference in the fusibility of the two metals.

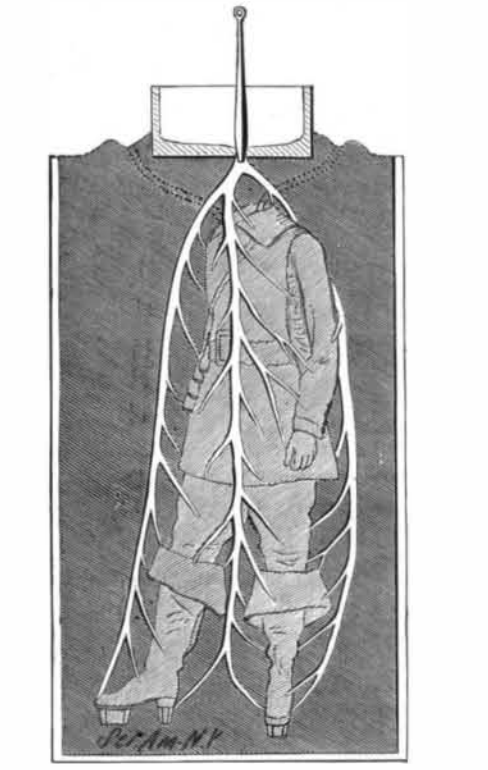
By means of gates, resembling somewhat a tree and its branches, as will be seen from the engraving upon this page, the metal is conveyed to every part of the mould. Three large or main gates lead down the back and sides of the figure, and from these extend the short branches, this insuring a rapid flow of the metal to every part of the mould. Passages are provided for the escape of gas, and within the core are placed "lanterns" formed of tin tubes designed to receive the gas formed in the interior.

The Pilgrim was cast in an upright position. On top of the flask was formed a reservoir capable of holding about 1,000 pounds of metal. In the bottom of the reservoir was an opening leading to the gates and closed by an iron plug. At each side of the reservoir was an opening into the mould, designed as an overflow, to show when the mould had been filled completely. The copper is melted in large crucibles, the tin being added afterward, the proportion here used being 92 copper to 8 tin. The reservoir being filled, a large crucible holding about twice as much more is brought by the crane until its contents can be poured into the reservoir. This great quantity of metal is required, since the bronze statue—9 feet in height—weighs nearly 2,000 pounds.

It is at this stage that one of the most delicate and important features in the whole work makes its appearance, and one upon which success directly depends. All hands wait until, in the judgment of the foreman, the bronze is at the exact temperature to insure a perfect flow. Too high or too low a temperature would ruin the casting. The men, who have that pride in their work which makes them as interested in the result as the proprietors, wait, ready to obey quickly and implicitly the orders given them. At the proper moment the plug is withdrawn from the reservoir and the crucible tipped. Pouring is continued until the metal flows out at the overflow holes, when it is known that the casting has been successfully performed. When cool, the statue is removed, the gates cut away, and the seams trimmed. The head, arm, and pedestal being joined to the body, the work is finished.

In casting the statue of Col. Wadley, the second one ever attempted in this way, the flask was placed at an angle, so shown in the frontispiece, the reservoir being at the upper corner.

The success attending these efforts is due to the experience and skill of the men, all of whom have been years in the business. The extreme care and attention they devote to every detail shows the great interest they feel in their work. The foundry is in charge of



CASTING A STATUE OF HEROIC SIZE.

Mr. John Pischof, while the finishing shops are under the control of Mr. Th. Lorme, both of whom have been for many years connected with bronze casting.

Sorghum.

At a recent meeting of the New York Chamber of Commerce, Dr. Peter Collier, who has made a special study of the cultivation and uses of sorghum, made an address, from which we extract as follows:

The history of sorghum with us only dates back to 1853, when William R. Prince imported from France a little sorghum seed, which Mr. De Montigny, the French Consul at Shanghai, China, had sent to the Geographical Society of Paris in 1850. In 1857 Leonard Wray, an English merchant, brought from Natal, South Africa, sixteen varieties of sorghum seed. To these last the name imphee was given, while the former was known as the Chinese sugar cane. And yet this plant, whose merit as a sugar producing plant appears to have been recognized thirty years ago, had come to be regarded as mainly valuable for forage or as a source of an inferior quality of syrup. It was a great error obtaining in Great Britain and on the Continent, as also in our own country, that the East Indians were a rice-eating people. Fully nine-tenths of them subsist mainly upon sorghum seed. In Turkestan sorghum is the main cereal, as, owing to the excessive droughts, no others could be successfully grown. In the northern part of China, sorghum was grown as maize is with us, and for the same purposes, and it so entirely satisfied the wants of the people that it had practically excluded maize. I have personally obtained within a few months from Calcutta eleven varieties of sorghum seed, twenty-one varieties from the Dharwar district in Western India, three from Hong Kong, three from Foo Chow, two from Senegambia—in addition to eight varieties from Northern China, three from Cawnpore, India, and twenty-two from Natal, South Africa; in all, seventy-three distinct varieties of sorghum—not one of these appearing to be identical with any of the numerous varieties cultivated in the United States; and it is to be remembered that none of these varieties has ever been cultivated in either of these countries for any purpose other than the seed and such forage as might be secured from the stalks and blades. Indeed, it is probably true that for the past thousand years the seed of sorghum has furnished food in greater abundance for both man and beast than have wheat and maize combined.

It is admitted that the demands upon climate and soil of the sorghum, as also the details of cultivation, are practically identical with those of maize, although it is a matter of moment that the sorghum, provided only it secures a good start in the early portion of the season, is capable of withstanding not only, but even flourishing during a drought which would prove fatal to maize. The chemical composition of sorghum seed shows it to be practically identical with maize; and for the purposes of food, or fattening, for the production of alcohol, glucose, or starch, the one may be substituted for the other, and there is no reason for any difference in their commercial value. Grown as Indian corn is grown, for the seed alone, sorghum is a crop of equal value with corn, and we are prepared to believe that upon a plantation properly located with regard to the mill and with economy in management, the seed will pay the entire expense of cultivation of crop and the delivery of the cane at the mill, as one of our largest sorghum planters has assured me.

It will be seen from tables which I present that the average amount of available sugar present in the juice actually expressed, from a crop actually grown, equaled 1,960 pounds per acre, while the amount of available sugar actually present in the crop, on the supposition of 90 per cent of juice, was an average of 2,853 pounds per acre. These certainly are astonishing results, and since they have been published, there have been, in certain quarters, persistent and continuous efforts to cast discredit upon them, despite the fact that a committee of the National Academy of Sciences (our highest scientific authority) had unanimously indorsed the methods by which these results had been obtained as being "among the best known to science."

The bagasse from sorghum contains not only a large amount of sugar, but other valuable food constituents, and it is, as it comes from the mill, in a mechanical condition admirably adapted for the silo and for eating. It appears from averages of a large number of analyses, that the actual money value of bagasse for food is almost exactly double that of ordinary ensilage; and since many of our farmers are engaged in preparing and feeding ensilage, it is worth while for them to consider the value for this purpose of the bagasse of the sorghum mills, at present used as fuel or for the manure heap. The bagasse, from which the sugar had been thus removed, was afterward submitted to the ordinary process for the preparation of paper pulp, and a sample was made, which, upon being submitted to one of our largest paper manufacturers, was pronounced to be of excellent quality, and worth four and a half cents per pound. A ton of cane would yield at least ninety pounds of such pulp, so that, with an average of ten tons to the acre, there might be made an amount of pulp worth $40.50. It is to be considered that each step in the process to which the cane is subjected increases its value for the production of pulp, and as there is nothing in the treatment which forbids its economical employment upon hundreds of tons of exhausted bagasse, there is reason to believe that ultimately this industry may be added to the production of sugar from sorghum cane, thus utilizing a waste product and increasing the profits on the crop. I think, therefore, that it may fairly be claimed for sorghum, from the facts which have been presented, that we have in it a crop fully the equal of Indian corn for its seed, and, in its stalks, fully as rich in sugar as is the sugar cane of Louisiana, and, besides, furnishing, in its bagasse, a material for the silo twice as valuable as common ensilage for food, or which bagasse may, by diffusion, yield at least an average increase in sugar and sirup of fifty per cent over that obtained by the mill, and then furnish to the manufacturer of paper excellent material for pulp.

Alleged Successful Treatment of Hydrophobia.

A native surgeon, M. Nursimula, has written a letter to the editor of the *Times of India*, from which it would appear that he has treated successfully a case having all the symptoms of hydrophobia. The treatment adopted was the subcutaneous injection of a sixteenth of a grain of atropia. The breathing became infrequent (12 per minute), and the pulse slowed to the rate of 50 per minute. A quarter of a grain of morphia was injected hypodermically as an antidote to the atropia, and this was repeated several times. The symptoms disappeared the third day after the onset of the malady. The patient was a soldier, aged twenty-four, who had been bitten by a dog the week before the symptoms resembling hydrophobia appeared. If the case were one of hydrophobia, it must be allowed that the period of incubation was very short; the dog is not stated to have been mad, and it must not be forgotten that the presence of symptoms closely resembling, if not identical with, hydrophobia does not *prove* that the case was one of genuine rabies.—*Lancet.*

Lead in Enamels.

A very rapid and handy mode of testing the enamel or tinning of cooking vessels, etc., for lead is recommended by M. Fordoz. The vessel is carefully cleaned to remove all grease, etc. A drop of strong nitric acid is then placed on the enamel or tinning, and evaporated to dryness by gentle heat. The spot where the action of the acid has taken place is now wetted by a drop of solution of potassium iodide (5 parts iodide to 100 of water), when the presence of lead is at once shown by the formation of yellow lead iodide. Tin present in the enamel, etc., does not give a yellow spot when the potassium iodide is added, the stannic oxide formed by the nitric acid not being acted upon.

A One Wheel Watch.

A curiosity in the way of watches was shown by Mr. E. Sordet, director of the Watchmakers' School at Geneva, before the horological section of the Society of Arts. This wonder is nothing less than a watch with one wheel, manufactured at Paris, in the last century, by a Mr. Gautrin. The watch was presented to the National Institute in 1790, being then in a deplorable state; but the teacher of the repairing section at the school, Mr. Emile James, has, after many hours of labor, succeeded in re-establishing harmony between the various organs, so that it is now in going order. The great wheel which gives the watch its name occupies the bottom of the case and the center of the plate; it has 60 teeth, and is 33 mm. in diameter. Its axis carries two pinions, one of which receives the motive force from a barrel, and the other carries the minute work. The function of this great wheel is quadruple. First it acts on a lift, then on a lever operating on another destined to lower the axis of the watch, and lastly on a third lever, the latter serving to return power to the great wheel at the moment when the action relents by the rise of the axis.

Value of Patent Property.

An illustration of the worth of a first class patent, for a device that everybody wants to use, is seen in the Bell telephone patent. The committee of three appointed by the Ohio Legislature to investigate the telephone companies in Ohio have prepared a report in which they say that there are about 12,000 complete sets of instruments in use in the State, all owned and controlled by the American Bell Telephone Company, of Boston. These instruments are leased to the local companies at an annual rental of $20 for each set, making the annual tribute paid by these local companies over $200,000. The cost of each set of instruments did not exceed $3.35. On instruments which did not cost the Bell company over $40,000, it receives over $200,000 annually. The Bell company, before granting a franchise to a local company, exacts from 30 to 35 per cent of the stock of the local company and from 20 to 25 per cent of the gross earnings of all toll lines. The committee declares that in its judgment the Bell company is an imperious and unconscionable monopoly, and should be restricted by legislation, or at least be taxed upon the commercial value of its instruments, and that it should be required to pay, in addition to the taxes upon its instruments, a tax upon gross receipts.

A new industry was created when the Bell telephone was invented, and great ability has been shown in the administration of the company's affairs from the commencement. To these facts the large profits are greatly due. Had the company's affairs been less wisely managed, probably it would not now figure before the Ohio Legislature as an "unconscionable monopoly," fit only to be plundered by the tax gatherers.

A Great Blast.

The San Francisco Bridge Company recently made a large blast with a view of obtaining 90,000 tons of rocks for constructing a sea wall at San Francisco. The quarry is a bluff, 60 feet high, at the water's edge at the mouth of Visitation Valley. Eleven tunnels in all have been run and four have been exploded, 11,000 pounds of Judson powder being used. Each tunnel was 50 feet long, and extended to an L, in which was the powder. From the L to the mouth of each tunnel rock and dirt had been "tamped" in as hard as possible. The four explosions were to occur successively, the first to loosen the cliff and make it easier for the second to become effective, and so on. The first explosion was awaited with some little apprehension by the harbor commissioners and other occupants of the towboat. But when it occurred, with a dull, heavy sound, and it became apparent that fragments of stone were not to fly through the air, there was a unanimous desire that the boat should move nearer the shore. The other explosions occurred soon after. No. 3 was a grand affair. A great section of the cliff was toppled over, and huge bowlders and tons of dirt rushed down to the water's edge. The blasts were pronounced successful, and the quality of stone, on subsequent inspection, seemed satisfactory to the harbor commissioners. It was estimated by the engineers that the 11,000 pounds of explosives had displaced in about 10 minutes 35,000 tons of rock and earth.

Spontaneous Combustion of Lampblack.

Fires occurring from spontaneous ignition of vegetable black are very common. Oily rags are more liable to self-ignition during the summer after a continuance of dry, warm weather. A sudden storm or a shower of rain appears to give life, as it were, to the parched-up matter, and a fire is the result. It has been also noticed that the reverse occurs after a continuance of wet weather. A few days sometimes are sufficient to set up active and rapid combustion, especially among sweepings in paint and oil stores, consisting generally of wood dust, dried vegetable and animal powder, colors more or less saturated with varnish, turpentine, oils, etc. Lampblack, if packed in a leaky cask when freshly prepared, condenses the atmospheric gases on its surface, which, owing to the porous nature of the substance, is very large in proportion to its weight. In condensation the gases give out a certain amount of heat, which under favorable circumstances is sufficient to cause the ignition of some inflammable substance accidentally present, which, by combining with the condensed oxygen, liberates heat enough to cause the ignition of vegetable black, which, when once started, soon spreads until the contents of the cask become red hot.

This spontaneous ignition is not infrequent in many large carriage factories, and builders' shops have been destroyed solely from this cause. To put it in printed paper would insure ignition from the absorption of the oil in the printing ink by the lampblack, generating gas which would soon ignite the soot or lampblack. One among many instances of well attested cases of spontaneous ignition is described in the *Paint, Oil, and Drug Review*. It occurred at a large carriage works at Grantham, England, in a shop far away from fire or the chances of a spark. The paint shop was gradually illuminated on a mild summer's evening during daylight. It was noticed through the workshop windows, and seen to be a tub of loose lampblack slowly consuming the cask. It was easily carried out on to the grass to finish its work. It was thought that, being near the grinding-paint stone, some oil had been splashed into it, or an oily rag dropped into the lampblack. The secret was soon found out by the palette knife being found among the ashes of the cask, having been carelessly dropped in with some wet paint on it; or even without any wet paint, the dry, oily paint which accumulates on the blade near the handle would be sufficient to cause ignition. It is not the large quantity of oil, but the small quantity, which is the cause of it. This is so well known, that some coach makers, when they receive lampblack, put it into a sound cask and pour enough linseed oil into it to saturate the whole.

AN ELECTRICAL STANDARD FOR MEASURING LIGHT.

Our large engraving represents a new form of arranging an incandescent electric lamp with reference to its use as a standard light for photographic purposes, and is the outcome of a long series of experiments by Mr. Thomas A. Edison and his assistant, Mr. John Ott, in charge of Mr. Edison's laboratory.

The problem of obtaining a steady light and a uniform current from a variable battery, with lamps of varying resistances, has been a puzzling one, but has recently been very ingeniously overcome; and it is our purpose to relate some of the incentives which led Mr. Edison to reach the result obtained.

During the past winter months the officers of the Society of Amateur Photographers, of this city, undertook to invent or provide some form of standard light which could be depended upon, to be used in testing the sensitiveness of different brands of gelatino-bromide dry plates. It occurred to them that possibly Mr. Edison might devise a uniform electric light, the actinic qualities of which, it was well known, would be invaluable for the kind of work to be undertaken.

The strength of the light required was to be equal to one candle power. When the matter was first introduced to Mr. Edison, he was of the opinion there would be no difficulty in obtaining a means of accurately measuring and controlling the resistance of such a small lamp, if a battery was employed.

The original plan was to interpose a known resistance in the main circuit with the lamp, which could be varied, and also an amperemeter or a voltmeter for measuring the variations of the current; but, after a large number of experiments, it was found impossible to make an instrument delicate enough to accurately measure the very low resistance in the lamp, which is said to be equal to about three-fourths of an ampere.

Mr. Edison then turned his attention to the utilization of the electrical compensation balance invented a few years ago by Prof. Poggendorf, which is generally recognized as being the most delicate method of measuring electro-motive force of batteries, and at the same time has the advantage of being entirely free from any detrimental polarization.

In this method of measurement the currents from two batteries are so balanced by the insertion of a variable resistance that, if a galvanometer is inserted in the circuit, no traces of a current can be perceived.

The arrangement as shown consists of a standard constant battery, a galvanometer, a key, a rheostat or resistance wire made in two sections, two parallel brass rods arranged directly above each section of the wire, provided with adjustable collars, which connect the bars to the sections of wire, and a switch, all fixed upon a base which rests upon a photometric testing box. Within the latter, supported upon a sliding board, is the standard electric lamp.

Hinged to this board is a long wood rod, which when the side of the box is closed, as it is intended to be for actual work, permits the operator to move the lamp at the open end to different distances from the sensitive plate, held in a plate holder slide, shown at the opposite end. The lamp is connected by flexible cords to the binding posts leading to the main battery and one of the sections of the rheostat wire.

The apparatus is intended to be used in the photographic dark room. The cell of the standard battery, S, is the standard by which the electro-motive force of the Fuller, or main lamp, battery, M, is measured.

The battery, S, which is comparatively new, was devised by Mr. Geo. Wirt, who is connected with the Western Electric Mfg. Co., of New York, and is a modification of the well-known Daniell battery. It is so constructed that the fluids cannot become disturbed or mixed through any slight jarring. It consists of three square bottles, $1\frac{1}{4}$ inches square by $4\frac{1}{2}$ inches high, with a neck $\frac{7}{8}$ of an inch in diameter by 1 inch long, securely clamped together with metal screw rods at the top and bottom, and held in an upright position by a light wood framework, as shown in the engraving. In the upper part of the adjoining sides of bottles I. and II. is drilled a small hole $\frac{3}{8}$ of an inch in diameter, and in the lower part of the adjoining sides of bottles II. and III. are similar holes, all arranged to correspond with each other.

A soft rubber washer separates the bottles at the holes, making a water tight joint, and also acting as a support to hold in place a thin film of gold-beater's skin, through which the liquids must pass by the process of endosmose and exosmose, from one bottle to the other.

All of the bottles are filled with a dilute solution of sulphate of zinc; within bottle I. is placed a piece of sulphate of copper about the size of a pea, which changes the solution to a blue color; the copper electrode at the bottom is connected by an insulated wire, which passes through the cork to the back of the key, K. At the bottom of bottle II. is a small chunk of zinc, which collects any deposit of copper, should any pass through from bottle I.

In the top of bottle III. is suspended the zinc electrode, which measures about $1\frac{1}{2}$ inches long by $\frac{3}{4}$ wide and $\frac{1}{8}$ thick; its conducting wire as shown passes directly to the galvanometer, G.

It will be noticed this arrangement gives a very constant battery which cannot polarize, as each electrode is completely isolated, and the separation of the bottles with the gold-beater's skin also prevents an easy mixture of the solutions. Each electrode is never endangered, but is kept immersed in a solution favorable to retain it in perfect condition.

The main or Fuller battery, M, has been somewhat modified, but consists of a zinc electrode inserted in the porous cup, in which has been placed a teaspoonful of mercury and a dilute solution of sulphuric acid and water.

In the glass jar are four carbon rods about one inch square, arranged to fit in each corner of the jar, connected by a ring of wire at the top to one conducting wire, which passes out through the top of the cell. The jar is filled with the usual bichromate of potash solution, known as electropoin. A metal screw cap secures a rubber cover to the top of the jar, and thereby prevents the evaporation of the solution. Six cells are employed, and are plainly seen, located on a shelf at the right, in Fig. 1.

The amount of resistance inserted in the series is a trifle more than the resistance of the lamp while hot, and consists of a length of $5\frac{1}{2}$ feet of German silver wire $\frac{16}{1000}$ of an inch in diameter, divided into equal sections connected together at one end, as seen in the diagram of Fig. 2, near the key, K, by a metal link. One section lies upon the millimeter scale parallel with and directly under brass rod No. 2; the other also lies on the board under brass rod No. 1. The section of resistance wire under rod No. 2 is electrically connected thereto by a hinged metal pointed foot and adjustable collar, which may be adjusted to any point on the rod over the millimeter scale, and is secured by a set screw. The position of this collar is never changed except when a new lamp is to be inserted in the circuit. The section of resistance wire under rod No. 1 is electrically connected to the latter by a sliding collar provided with a spring, at the end of which is a grooved brass wheel about $\frac{3}{8}$ of an inch in diameter, which bears directly upon the wire.

In the diagram, Fig. 2, the arrangement of the apparatus will be seen more clearly. S represents the "standard battery," G the galvanometer, No. 2 brass rod with fixed collar, No. 1 brass rod with movable collar, R resistance wire, which also connects with wire under rod No. 2, K key in the circuit of standard battery, L the electric lamp.

In order to intelligently understand the operation, we will detail the two different circuits of the batteries.

The circuit of the Fuller battery, M, is from the positive or carbon pole of the battery to brass bar No. 1 (see Fig. 2), through the collar, spring, and wheel to the German silver wire, R, to the lamp, L, and then back to the negative or zinc pole of the battery. It will be seen that by sliding the collar on rod No. 1, the amount of resistance in this circuit is easily increased or diminished.

The circuit of battery S is from the positive or copper pole through the key, K, to the resistance wire, R,