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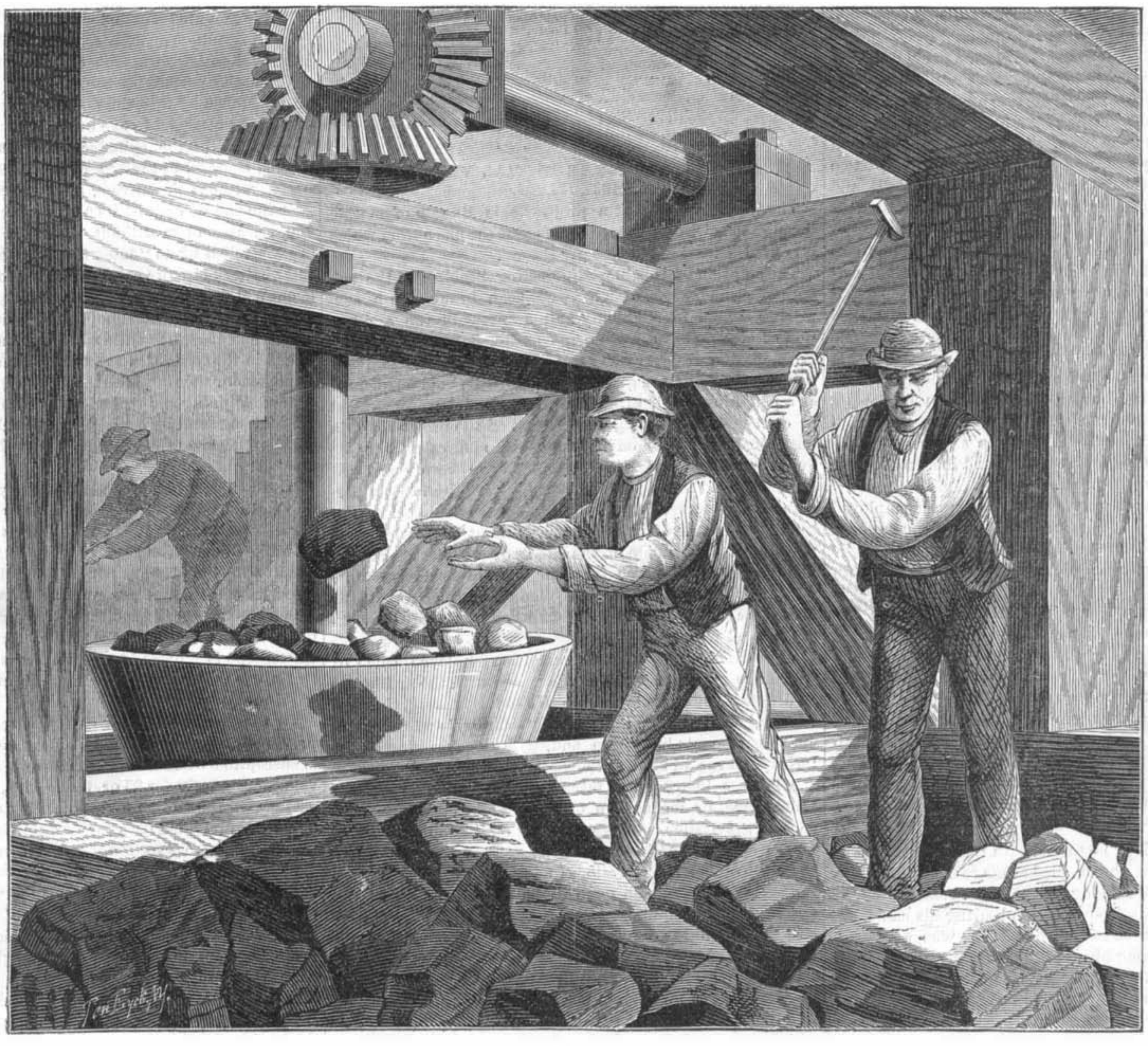
THE MANUFACTURE OF PLASTER OF PARIS.

BY J. F. GESNER, M. A.

Gypsum is a mineral, very widely and abundantly disseminated, whether as the snow white, translucent, and massive alabaster, the transparent, crystallized selenite, the fiberous, beautiful satin spar, or the ordinary amorphous, rather soft plaster stone. It is only when ground and calcined that the term plaster of Paris is applied to it, from the great extent of gypsum existing at Montmartre, near Paris, where it has been worked for a long time.



THE MANUFACTURE OF PLASTER OF PARIS.

The many beautiful objects of art into which alabaster is formed, such as vases, monuments in churches, statues, etc., are familiar enough to many. The softness of the stone, and its rapid deterioration when exposed to the weather, render it adapted only for statuettes and other small works of art, or for those which are not intended to be exposed to excessive moisture or climatic influences.

The crystallized and transparent form of gypsum, frequently found in large deposits of the ordinary stone, is known as selenite, from *selene*, the moon, on account of its reflecting a soft moon-like luster. This variety is capable of splitting up into thin laminæ or leaves, sometimes of large size.

The beautiful satin spar is a fiberous variety of gypsum, and exhibits a fine play of light, like lustrous satin. It is used for necklaces, inlaid work, and other ornamental purposes, though it is easily scratched and its beauty destroyed. Anhydrite is the term applied to a hard compact variety, which is remarkable from the fact of its containing no water; it is consequently inapplicable, as will be seen more clearly presently, for the process and uses which we are about to describe.

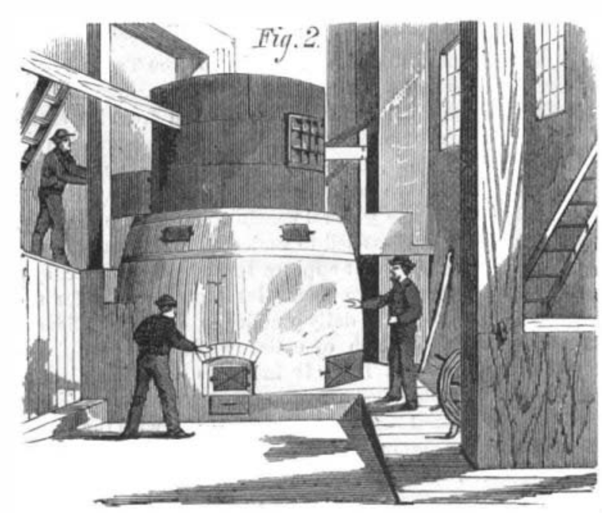


Fig. 2.

The ordinary amorphous form of gypsum, or plaster stone, of which we have to treat in this article, is a sulphate of lime, containing, in 100 parts, 46·51 parts sulphuric acid, 32·56 parts of lime, and 20·93 parts of water. It is the peculiar way in which this water is held, its easy expulsion by a moderate heat, and the subsequent readiness of the material to combine with the abstracted water, when again presented to it, and assume the solid state, that give to gypsum its importance in the useful arts, and make its manufacture on the large scale a great and increasing industry.

In its composition will be noted how substances, highly corrosive in themselves, sometimes unite to form inert and harmless compounds. Confectioners largely adulterate their sugar plums with very finely ground or elutriated gypsum.

Gypsum, in the ordinary state, as largely quarried, resembles good limestone or carbonate of lime; but it differs from it in not, when pure, effervescing with acids and in being softer. It is indeed unattacked by acids; but by the action of water it is gradually dissolved and washed away, 1 part requiring 400 parts of water for its solution.

When crude gypsum in any of its forms, except anhydrite, is heated to 212° Fah., it begins to lose its combined water, and parts with it entirely at 272° Fah. If it be now withdrawn from the source of heat and, in a powdered condition, mixed with water, it combines with the same quantity previously expelled, and sets or becomes solid as at first. The operation of driving off this combined water is termed calcination.

We come now to the processes connected with the treatment of gypsum for rendering it available for the arts. The principal treatment, on which everything may be said to depend, is the calcination, or the exposing of the stone to that degree of heat which is just sufficient to expel enough water, so that the powdered material, when mixed with water, will set rapidly into a solid mass. This can be effected in two ways, either by exposing the hard crude stone, in small lumps, to the direct action of flame, or by submitting the crude powdered material to an indirect source of heat. The first method is practiced in Europe, where the crude gypsum is burned in kilns, similar to those used for lime, or sometimes in those of more improved construction, but in which the stone is still exposed to a direct fire.

The disadvantages attending this method are that the lower layers of stone are "dead burnt," so that their powder will not set with water, and the upper layers are apt to be insufficiently dehydrated, giving rise to the same evil. Many pieces of gypsum, moreover, when taken from the kiln, are found to contain a core of raw plaster, which of course is incapable of setting solid. After calcination, the stone found to be sufficiently burnt is powdered and packed for use.

The great demand for calcined plaster, and its cheapness for building purposes, have caused large steam mills to supersede the old-fashioned method of manufacture.

By the kindness of Messrs. Wotherspoon Brothers, proprietors of the Phœnix Plaster Mills, in West Thirteenth street, New York city, our artist has been enabled to make a series of drawings which will help to explain the various processes of the manufacture. The large illustration (Fig. 1) shows the operation of breaking and crushing.

The crude gypsum which, when brought to the mill, is in masses weighing from 20 to 100 lbs. or over, is broken up by the hammer into pieces rather smaller than an ordinary paving stone, and thrown by the workman into the crusher. This consists of an upright shaft expanding below into heavy iron cogs, which turn in an exterior iron shell, as seen in Fig. 1. The stone is here rapidly reduced to powder, but not yet sufficiently fine for the calcining process. A pulley below conducts the powdered material, by means of cleats revolving in an inclined wooden pipe, termed a conveyer, to the floor above. This style of conveyer is used in flour mills, and is located on the left of the crusher in the engraving. Here the crushed plaster is fed by a hopper, like wheat, to a burr stone mill, which reduces it to a fine powder, ready for the calcining process. Another conveyer, similar to the one described, carries the fine raw plaster to a bin at the top of the

Fig. 3.

building, where it is delivered in successive charges to the kettles. These, as shown in the illustration (Fig. 2), consist of large cast iron receptacles, capable of holding 45 barrels as a charge. They are set in brick furnaces and their bottoms are constructed in a peculiar manner and of stout iron, to withstand the heat of an anthracite fire. Revolving stirrers, almost in contact with the bottoms and sides, are kept in motion to prevent caking.

Care and skill are requisite in the calcination process, to avoid either over or under burning. If all the water be driven off, the plaster will not harden so rapidly as that which has been heated so long as the tumultuous expulsion of vapor lasts; and if only half the contained water be expelled, the plaster will have entirely lost its power of hardening with water. Properly calcined gypsum seems to retain one fourth of its combined water. When the calciner judges the process to be complete, the calcined plaster is drawn out into a bin, where it is conducted to the bolt, which is a revolving cylindrical drum made up of three different finenesses of wire cloth set on an incline. The finest sieve is first encountered, and then the material falls upon the others in turn. Directly below, corresponding to the width of each particular fineness of the sieve, are bins which receive the calcined plaster of three degrees of fineness, known as superfine, casting, and common. From these bins the article is rapidly shoveled into barrels and packed for the trade.

The method of packing is seen in the illustration, Fig. 3. The workman first prepares the barrel by lining its interior by hand with a few sheets of brown paper, wide enough to overlap one another. These project above the top of the barrel, and are folded over in a very secure manner, thus answering the purpose of a head. Barrels for distant transportation are headed in the ordinary manner.

The barrel to be filled is first fitted with a wide mouthed funnel, and then placed on a revolving platform, and, while rotating slowly, is tapped rapidly by a hammer actuated by a spring and ratchet wheel. Each shovelful is thus well packed.

This manufactory of the Messrs. Wotherspoon has been in operation over forty years, and utilizes the product of two quarries, one at Wentworth, near Windsor, Nova Scotia, and the other at Hillsboro', New Brunswick. The establishment is capable of turning out about 2,000 barrels per week.

Among the uses of plaster of Paris may be noted its employment for a hard finish to walls and the molding of cornice ornaments, for which purpose, to prevent its too rapid setting, it is usually mixed with a due proportion of slaked lime.

A remarkable fact connected with calcined gypsum is that the addition of two per cent of alum or borax delays its setting three or four hours, but the material then becomes a stone-like body, heavier than ordinary plaster. In Germany, Italy and England, beautiful cements are made in this way, known as parian. In taking casts, and in stereotyping, plaster of Paris is largely used.

Besides its use for molds in potteries, gypsum is employed for glazing porcelain; and, being an excellent non-conductor of heat, for filling fireproof safes. In Spain and France, made into a mortar with sand and quicklime, it is used for cementing floors and vaults.

In the United States, gypsum is extensively used as a fertilizer, and is found to be very efficacious on some soils. It is used as a top dressing for grasses, and for potatoes and turnips, but the grains do not require it. Liebig has pointed out the fact that it fixes the ammonia of the soil as well as that of the atmosphere, thus conveying nitrogen to the roots.

The best gypsum quarries that are worked on this continent are on the Bay of Fundy, Nova Scotia, and Hillsboro', New Brunswick. Over one hundred thousand tuns of the finest quality are annually imported into the United States.

MR. SETH ADAMS, long identified with the commercial and mechanical interests of Boston, died at his residence in Newton a few days ago after a long illness. Mr. Adams was the inventor of the celebrated power press bearing his name, but left it for improvement to his brother Isaac, who afterward became celebrated among printers for his many contrivances for facilitating the art of printing. He had a large property, which was invested in various corporate enterprises.

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Contents.

(Illustrated articles are marked with an asterisk.)

MEASUREMENT OF THE INITIAL VELOCITY OF PROJECTILES.

The initial velocity of a projectile is its rate of motion through the air, at or near the muzzle of the piece from which it is fired, expressed in feet per second.

The solution of this most interesting problem in the science of gunnery has, of late years, been brought to a surprising degree of simplicity and accuracy by the application of electricity to instruments designed for the purpose. Formerly the problem was solved by determining the quantity of motion of the gun with its charge, etc., suspended as a pendulum, and, afterwards, the results were verified or corrected by receiving the impact of the projectile on a butt, suspended also on a pendulum, and calculating its quantity of motion. Both methods have been employed separately and in conjunction, but they required costly permanent structures, and gave but indifferent results.

The importance of this problem, without a knowledge of which no true estimate of the effects of a projectile can be formed, led to the search for a more accurate solution of it, which has resulted in the production of the electro-ballistic pendulum and chronoscopes now used by the artillery experts of all nations.

Many different instruments have been employed, some of which are still in use and are favorites with the artillerists of different countries. In the United States service, the "Navy," "Bruton," "Vignotte," "Schultz," and "Boulonger" instruments have been and, with the exception of the "Navy," are still used.

All these instruments measure very short intervals of time; some, by means of a falling weight under the influence of gravitation; others, by the oscillation of one or more pendulums of known length; and others, by the isochronism of musical vibrations; and, besides measuring an interval of time, enable us to divide it into fractional parts and record its beginning and end, by means of electricity, either through the influence of electro-magnets, or by the spark from an induction coil.

As a representation of the first class, the Bruton instrument will serve for description. It consists of a graduated semicircle, supported on a tripod vertically, in front of which two pendulums, of equal length, are suspended on journals whose axes are on the same plane. The pendulums oscillate freely, close to the arc. The inner has an arm or marker on its end, which is struck by the outer one as they pass one another. An electro-magnet at each end of the diameter of the semicircle serves to hold the pendulums in a horizontal position, ready for recording. Each magnet is connected with a frame, the first near the muzzle of the piece and the second 100 feet farther on in the path of the projectile. Across each frame, the wire from its respective magnet and battery is passed to and fro, at such distance as will insure its being broken by the projectile in passing through. The battery circuits can be closed and broken at will, by means of a disjunctor.

To test the adjustment of the instrument, the circuits are closed, and the pendulums brought into contact with their respective magnets, where they remain in a horizontal position. The disjunctor is made to break both circuits simultaneously, the magnets become passive, and the pendulums begin their oscillation; they meet or pass one another at the lowest point of the arc, which for convenience is called the zero of the graduation; and at this point a mark is found, near the scale, indicating the place at which they passed. A spring receives each pendulum as it completes a single oscillation and holds it until released for another experiment. The trial thus described having shown that all is in order, the circuits are again closed, the pendulums suspended from their magnets, and the word "fire" is given. The projectile passes through and breaks the first target, and the corresponding magnet releases its pendulum, which begins an oscillation; meanwhile the projectile has advanced to the second target, breaks it, and the corresponding magnet and pendulum are similarly affected. In this case the pendulums, not beginning their oscillations together, do not meet at the zero point of the arc, but some distance to one side of it, where the mark indicates the number of degrees from zero at which they passed. The time of oscillation of the pendulums being known, the short arc enables us to find the time between the fall of the first and second pendulum, which equals the time occupied by the projectiles in passing from the first to the second frame or target; and the space between the targets divided by the interval of time gives the initial velocity. For example, suppose the value of the interval to be one tenth of a second, and the space passed over to be 100 feet, then: $100 \div 0{\cdot}1 = 1{,}000$ feet per second.

The Benton instrument was invented by Major J. G. Benton, of the United States Ordnance Corps. It is probably the best of the pendulum instruments; and, for measuring velocities by means of a single interval of time, is unequaled for general accuracy and ease of manipulation: but a pendulum instrument is limited to this use, and involves sources of error which later ones of different construction are intended to overcome, by discarding the pendulum and adopting a more sensitive agent to indicate the very small intervals of time required.

Preëminent among these stands the instrument invented by Captain Schultz of the French artillery, and known as the "Schultz chronoscope." It consists of a bed plate on which is mounted a cylinder with clockwork and a screw to give it simultaneously a rotary and lateral motion on its axis; a vibrating fork, whose function it is to trace a scale of time on the surface of the cylinder (which has been previously smoked by the flame of an oil lamp), by means of a quill point attached to one of its arms and resting lightly on the surface of the cylinder, in front of which the fork stands, clamped to the bed plate. The fork is made to vibrate, without fluctuation, by an electro magnet mounted near the end of each of its arms, which alternately attracts and releases them without contact. The electro-magnets are controlled by an "interrupter," which closes and opens their battery circuits as often as the fork vibrates, which is about 500 times per second.

The rotary and lateral motion of the cylinder cause the fork, when at rest, to trace a fine line on its surface from end to end in the form of a helix or spiral, and, when the fork is in vibration, the sinuous line it traces intersects this fine line at the beginning and end of each vibration. The "rate" of the fork is found by connecting a break circuit seconds pendulum with the primary wire of the Rhumkorff coil, whose secondary wire delivers an induction spark on the surface of the cylinder, beside the trace, every second; the number of vibrations between each spark shows the rate of the fork per second, which rate is constant for the same fork.

In like manner the rupture of the target wire (which is in circuit with the primary wire of the coil) by the bullet gives a spark for each, and the number of vibrations traced between the two sparks indicates the time the projectile took to pass from the first to the second target. A micrometer microscope is provided to read fractions of a vibration, and by its use the value of the interval can be determined to within $\frac{1}{50000}$ part of a second.

This instrument is not so easy to manipulate as the one previously described, but it yields more accurate results and is susceptible of more extended use. It will record intervals continuously for 25 or 30 seconds, and so permit of investigating the motion of a projectile through its entire time of flight, and yield data for determining the resistance of the air on its cross section. It has been used to measure the time of passage of a musket bullet over the space of one foot, the average of ten trials being 0·000914." It may also be used to investigate the motion of the projectile within the bore of a gun, an experiment which has been recently made by Captain Noble, of the English service, with a chronoscope of his invention, in which rapidly revolving disks, of almost uniform motion for short periods of time, serve to receive the electric record from the targets.

The *data* furnished by such experiments are of the highest importance in the selection of suitable powder for guns of various calibers and the best forms of projectiles, and the instruments just described are fully equal to the solution of all the problems of modern gunnery lying within their field of research, and may well be expected to hold their preëminence for many years to come.

THE PRACTICAL ASPECT OF THE EIGHT HOUR LAW.

Supervising Architect A. B. Mullett of the Treasury Department, in his recent annual report, cites various forcible objections to the eight hour system, gleaned from his experience in the employment of labor in the construction of government buildings, since the passage of the act of Congress fixing the above number of hours as a legal day's work. He draws the general conclusion that the practical operation of the law has led to undesirable results.

In brief and generally, it appears that the eight hour system means not merely two hours less toil per day for the workman, but two hours daily practice in habits of idleness with their attendant train of evils; while to the employer and the community at large it indicates a deprivation of useful and valuable labor in a proportion constantly increasing, above its initial limit of twenty per cent, with the length of time the plan is in existence.

Mr. Mullett, in his communication to the department, states the more especial objections to the law, as follows:

"I desire once more to call attention to the eight hour law, believing it to be alike injurious to the best interests of the government and to the workmen themselves. It frequently happens that mechanics and laborers employed by