

be furnished with electric footlights, curtain, and scenery. The seats slope down from the rear, and the intention is to furnish plays and concerts for the insane criminals once a week at least, the doctors agreeing that such attractions induce good behavior and become valuable auxiliaries in effecting a cure of slighter mental ailments.

The bars at the windows are made of chrome steel, and like those in use in banks and safe deposit vaults, are warranted to defy file or saw. Accommodations are provided for 500 guests, but on a pinch twice that number of insane can be cared for comfortably.

The kitchen, 40 x 70 feet in dimensions, surrounded by immense bake ovens, steward's pantries, closets, and store rooms, is at the extreme end of the buildings. It is metal roofed, has hard wood doors, with oak and yellow pine casings and a closely knit pine floor. The ceiling is very high, with large openings to drive out smoke and smell.

Passing out at the door and across the grounds a distance of fifty feet, the visitor is led into a heavy brick building, which contains five boilers, each six feet in diameter and twenty feet long. Adjoining is the dynamo building, and between them towers an immense smokestack of brickwork neatly turned and stone-capped summit. Next to it is a five story water tower, which receives its supply from the village reservoir on the mountains near by, with sufficient force to flood the vast buildings in half an hour. Fire, panic, and loss of life are believed to be an utter impossibility.

The dimensions of this wonderful asylum prison, as furnished to *The World* by the contractors, are:

	Feet.	
Main buildings.....	600	x 54.4
Administration wing.....	112.6	x 96.6
Amusement hall.....	46	x 68
Six wards, each.....	35.8	x 70
Six dormitories, each.....	85.8	x 70
Kitchen.....	46	x 54
Male dining room.....	85	x 54
Female dining room.....	70	x 15.5
Boiler house.....	54	x 86
Dynamo building.....	47	x 84
Water tower.....	25	x 37

The work of contractors Sullivan & Clarke cost \$800,000, exclusive of grading, lighting, heating, and plumbing. The electric light plant, with wiring and lamps, cost \$50,000, and the remainder of the \$1,000,000 expended by the State was devoted to the purchase of land, preparing it with drainage and plumbing, heating, and furnishing the buildings. Shade and fruit trees will be planted on the grounds, and in a few years it will be one of the garden spots on the Hudson River.—*N. Y. World*.

BAROSCOPIC THERMOMETER.

UP to the present, all thermometers, other than mercurial and alcoholic ones, have generally been based upon the principle of the *deformation* of a body by expansion. The instrument that may be regarded as the type of this kind is Breguet's metallic thermometer.

These apparatus all offer the same inconvenience; after operating a certain length of time, the dilatable body constituting the thermometer undergoes, through successive twistings, certain molecular modifications that change the structure of it, so that the same variation of temperature no longer affects it in the same way that it did at the time that the apparatus was graduated. The readings are therefore no longer accurate, and the effects becoming marked in the long run, the instrument is put out of service.

The object of thermometers of this kind is to obtain the displacement of a movable object (say a needle) capable of being easily seen at a distance, or to establish contacts with determined points. Now, in order that the movable object may be capable of being displaced, it is necessary that it shall be submitted to the action of an initial force, the result of a change of temperature, and such force has generally been sought in the deformations of some substance.

The baroscopic thermometer is designed to overcome such irregularities of operation, through the use of a motive force which, really invariable, always produces the same effects for the same causes.

This force is gravity. In this apparatus there is utilized the weight of the volume to which the body expands; in other words, instead of employing, as an initial force, the breaking of the *geometrical equilibrium* of a body, we utilize the breaking of its *static equilibrium* in assimilating the expansible body to a balance, that is to say, to a lever of the first kind, one of the arms of which is formed of the expansible material, and the other of the expanded part of this same material. It is evident that, with the elevation of the temperature, the second lever arm will increase in weight to the detriment of the first. It will therefore descend, and we shall here have a utilisable force. If care be taken to select for an expansible body a material not subject to molecular variations of structure, it is clear that to a same elevation of temperature there will always correspond a like expansion and therefore a same motive force.

The body employed is mercury, the fluidity of which perfectly adapts it to the construction of the apparatus, and the uniformity of expansion of which secures a perfectly regular operation. Moreover, the great density of this metal gives a great increase of force for a slight increase of temperature.

In principle, the baroscopic thermometer devised by Mr. Debaecker is therefore an ordinary thermometer held in equilibrium by means of a horizontal axis passing through its center of gravity. If the temperature rises, the mercury will expand in the thermometric tube, which will become more weighty and will incline. In case the temperature falls, a contrary effect will follow, and the tube will rise, thus producing an alternating motion capable of being utilized.

The principle upon which the baroscopic thermometer is based being true, it might be constructed of as small dimensions as possible; but what is correct in theory ceases to be so in practice when it is necessary to dispose of an appreciable force in order to render the apparatus sufficiently sensitive and to compensate for the work absorbed by the movement of the parts.

The inventor was therefore led to give the mercurial reservoir quite large dimensions, in order that the

weight of the volume expanded might have a value capable of actuating the apparatus. We shall calculate this value further along.

The thermometric reservoir, V, carries a tube, S, of small diameter which terminates in a volution, α , whose spirals are so arranged that the whole constitutes a spherical calotte whose center coincides with the axis of rotation of the apparatus. This arrangement was adopted in order to avoid giving the tube too great a length, and also in order that the center of gravity may not be sensibly displaced, whatever be the quantity of mercury contained in the spirals.

The tube, S, is placed in a sort of gutter, Z, of metal, which serves to support it, and which is fixed to a piece of metal, A, that carries the axis formed of the two knives, B, of steel or other hard material, resting upon supports, R, also of steel or other hard material.

The height of the knives is sufficient to allow the

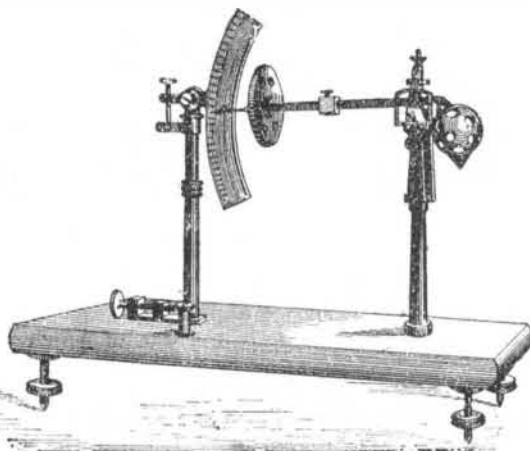


FIG. 1.—DEBAECKER'S BAROSCOPIC THERMOMETER.

horizontal axis of rotation, constituted by the conjunction of the knives and supports, to be situated a little above the center of gravity of the apparatus. A regulating screw, M, placed at the upper part of the piece, A, permits of varying the sensitiveness. In the center of the spherical calotte formed by the spirals there may be fixed either an indicating needle, E, or any movable device capable of producing contacts, if it be desired to use the thermometer for indicating the variations of temperature at a distance. However, the inventor is now putting the last touches on a very complete registering apparatus designed to be actuated by the thermometer.

Calculation of the Thermometric Reservoir, V.—In order to simplify this calculation, we shall take account only of the expansion of the mercury contained in the reservoir, without occupying ourselves with that which is in the small tube, and the expansion of which is practically of no consequence.

Let f be the motive force that it is desired to obtain for a variation of 1° of temperature, and let $\frac{1}{m}$ be

the ratio existing between the distances that separate, respectively, the point of suspension of the apparatus from the center of gravity of the reservoir and from the center of gravity of the small tube and its spherical volution constituting the long arm.

If we deduct from the reservoir a weight, p , the effect produced is the same as if there had been added

to the long arm a weight $\frac{p}{m}$. On another hand, if we now add to this arm this same weight, p , it will act with

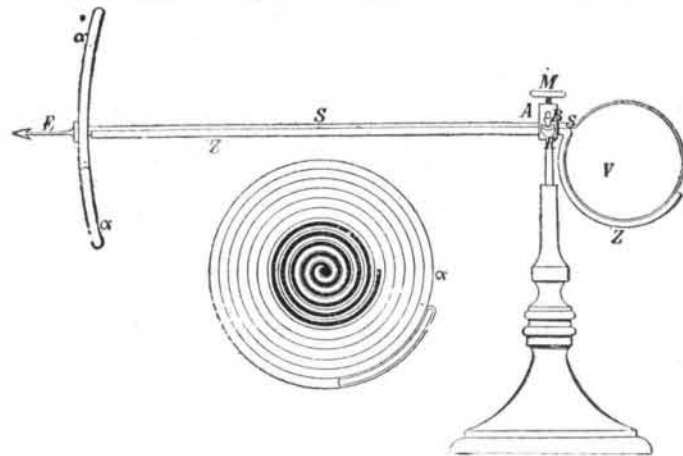


FIG. 2.—DIAGRAM OF BAROSCOPIC THERMOMETER.

a force equal to its own value, and the total effect produced to influence the tube will be equal to

$$p + \frac{p}{m} \quad (1)$$

We shall therefore have

$$f = p \left(1 + \frac{1}{m} \right) \text{ or } p = \frac{m \cdot f}{m + 1}$$

of expanded mercury necessary to cause the apparatus to operate with a force, f . This weight corresponds to

$$a \text{ volume } v = \frac{d}{p} \text{ } d \text{ being the density of the mercury.}$$

Now, as this quantity v is necessarily the increase of the volume V of the reservoir for 1° of temperature, we shall have

$$v = V \cdot \alpha$$

α being the coefficient of the apparent expansion of the mercury.

We deduce from this:

$$V = \frac{v}{\alpha}$$

and finally

$$V = \frac{m \cdot f}{\alpha \cdot 2(m + 1)} \quad (2)$$

It will be seen from formula (1) that the difference of length of the arms is unfavorable in the sense that the weight of the quantity of mercury displaced acts with so much the less force in proportion as the ratio is greater; but this arrangement has been employed in order to render the apparatus lighter, and therefore more sensitive. The maximum effect will be obtained with arms of equal length, for the weight p will then act with a force equal to $2p$.

In order to establish the graduations, the formula of the sensitiveness of the balance is taken as a basis—a formula that gives the tangent of the angle described by the beam for a given load.

Instead of a spherical reservoir of wide diameter, the mass of which requires a certain time to take the temperature, it would be possible to adopt a spiral reservoir that would be more sensitive.

Finally, in order to render the apparatus lighter, mercury might be left only in the long arm, and the reservoir might be filled with alcohol, which is very expansible. But this arrangement would diminish the precision of the instrument. Moreover, it has been tried already without much success.—*Le Genie Civil*.

THE PRACTICAL APPLICATION OF MAGNESIA CEMENT.*

By CARL OTTO WEBER, PH.D.

THE name of cement is applied to a certain class of chemical compounds which, when in the form of a fine powder mixed with water, within a certain time form a solid homogeneous mass of stone-like appearance and great hardness. One class of these cements, which we may roughly term alumina-lime silicates, has developed into an industry of the highest importance, producing millions of tons every year, although it is hardly 70 years since the beginning of the manufacture of these products on a large scale. The literature, scientific and technical, of this branch of chemical manufacturing is of extraordinary dimensions, which is, however, not very astonishing, if we consider on the one hand the commercial importance of the article, on the other hand the very great complexity of this matter from a scientific point of view.

There exists, however, besides the silicate of lime cements, a very great variety of other cements, some of which are used in workshops every day, but offering, neither commercially nor scientifically, much to interest us. As competitors with the alumina lime silicates they are altogether out of the question. But there is a class of cements, the magnesia cements, which certainly are deserving of more attention than has been paid to them up to now, although I do not mean to say that they will ever rival ordinary cement in any considerable degree. But on the other hand there can be no doubt that these cements might easily find a considerable sale, so soon as the means are found to overcome certain unwelcome properties of them, which are the main impediment to their use.

The hydraulic properties of magnesium oxide have been discovered by Vical, the same man who may be considered the founder of the silicate of lime cement industry. Vical observed that freshly calcined magnesia hardens in contact with water, an observation which was confirmed by Macleod, but neither of the two seems to have followed up this experiment any further. The matter rested for more than forty years, when Deville discovered that magnesia, obtained from chloride of magnesium by calcination, and carbonate of lime formed a cement which under water sets to a mass in its outer appearance very much like marble, but considerably surpassing this material in hardness.

Deville found that the hardness these cements attain depends largely upon the density of the magnesia used.

Magnesia salts precipitated with alkalies yield a magnesia of great hardness, forming cements of a very poor quality, whereas the magnesia obtained from chloride of magnesium by calcination is of great density. To use Deville's method for the production of this cement on a commercial scale is out of the question for economical reasons. But considering the composition of Deville's cement, magnesia and carbonate of lime, it is not surprising that experiments have been made with a view to utilize dolomite, a natural magnesia-lime carbonate, for the manufacture of the product in question.

If dolomite is heated to a temperature below red heat, the carbonic acid of the magnesia carbonate, but not of the lime carbonate, is given off and the resulting product is Deville's cement. On further investigation of this matter, Grace Calvert found that the hydraulic properties of this cement increase with the

* Lately read before the Manchester Section, Society of Chemical Industry.

proportion of magnesia which it contains, and that in strength and durability it is equal to a good average Portland cement. This standard, however, was subsequently contradicted by Erdmenger, who found these dolomite cements very much inferior to the average Portland cements.

The interest which this class of magnesia cement at one time attracted by and by subsided, and to-day the question of dolomite cements has sunk nearly into oblivion. If we take into consideration that dolomite cements could be profitably produced at about two-thirds of the price of Portland cements, it is obvious that their qualities must be of such an unsatisfactory kind as to render them unfit for successful competition with the silicate of lime cements.

At about the same time Deville made his researches on the magnesia lime carbonate cements, Sorel discovered his magnesia cement, which he described as magnesium oxy-chloride. He produced it by forming a paste from a finely ground magnesium oxide and a solution of magnesium chloride from 30 to 70 per cent. strong. This cement, which sets tolerably quickly, forming a very hard mass, considerably harder than marble, gives extraordinary high figures in the crushing test, and possesses a tensile strength equal to nearly one ton per square inch, which is about three or four times the tensile strength of a good Portland cement.

It has the further advantages of being fairly cheap, producing splendid concretes with as much as ten times its own weight of indifferent materials, and having a beautiful white color, so that it appears scarcely doubtful that if magnesia is going to win a place among the important cements, it will be in the form of Sorel's cement or some improvement thereon.

One of the most important items to be observed with magnesia cement is to use a magnesia of great density and as free as possible from carbonic acid. A few per cent. of carbonic acid absorbed by the burnt and powdered magnesia are sufficient to so considerably interfere with its action as to render it absolutely useless. The reason of this is, not that the magnesium carbonate formed, by its chemical properties, prevents the formation of a cement from the unchanged magnesia on the interaction of the solution of chloride of magnesium, but that the magnesium carbonate envelops each particle with a film entirely indifferent against magnesium chloride, and although in the center of each such particle the cementation takes place, that outside film of carbonate prevents the action from particle to particle, *i. e.*, the agglomeration of the whole mass. A few days' exposure of the magnesia to the atmosphere is quite sufficient to make this substance unfit for use.

The magnesium chloride used for Sorel's cement is the ordinary product as it is used largely in textile industries. It is sold in casks, in which it forms a solid block of white color and crystalline texture, containing about 48 per cent. of pure $MgCl_2$. Of this salt Sorel recommends the use of a solution from 30 to 70 per cent. strong, but I found the results obtained are the more satisfactory the stronger the solutions used, and consequently I always use solutions about 80 per cent. strong.

If from magnesia and such an 80 per cent. solution of magnesium chloride a paste is formed, it sets within a few hours to a solid white mass, the hardness of which still increases for some days. The time of setting to a great extent depends upon the temperature and the moisture of the air at the time the experiment is made, high temperature and little moisture considerably accelerating the setting, whereas low temperature and moist atmosphere show a decidedly restraining influence.

The proportions of magnesia and magnesium chloride are of the greatest influence upon the qualities of the cement. I stated before that the cement produced was the harder the stronger the solution of magnesium chloride used, and this fact was already pointed out by Sorel himself. This might seem to imply that the hardness of this cement could be improved by increasing the proportion of magnesium chloride which enters in the composition. But this is not so. The fact is that in working the cement with an 80 per cent. solution of magnesium chloride, the strength of the cement decreases with increasing proportions of the chloride. The following series of experiments show this very clearly:

No.	MgO	$MgCl_2$ 6 aq. 30 Per cent. Sol.	Tensile Strength per Inch Square.
1*	10	6	1,748
2	10	8	1,300
3	10	10	1,150
4	10	12	1,028
5	10	14	860

* Besides the above proportion of magnesia and magnesium chloride $\frac{1}{2}$ part of water was used, as without this the mixture appeared quite dry and had no plasticity.

This shows distinctly enough that a mere increase in the proportion of the magnesium chloride is detrimental to the cement, a fact which becomes still more prominent some time after the experiment, when first hair cracks appear on No. 5 sample, which in due time develop into gaping fissures, owing to a swelling of the cement after setting. Samples 3 and 4 show the same phenomenon, only in a somewhat smaller degree, the amount of swelling being distinctly in proportion to the amount of magnesium chloride the samples contain. Samples 1 and 2 remain perfect for any length of time.

Considering these facts, we must come to the conclusion that if the stronger chloride solution produces stronger cements than a weaker chloride solution, this is not due to the relative increase in magnesium chloride, but to the decrease of the water of the solution. The correctness of this conclusion is borne out by another series of experiments. Sample No. 1 of the previous series showed the highest tensile strength and stability, and to find out the influence of water, or what comes to the same, of solutions of magnesium chloride less than 80 per cent. strong, I added to the various cement mixtures varying quantities of water:

No.	MgO	$MgCl_2$ 6 aq. 80 Per cent. Sol.	Water.	Tensile Strength per Inch Square.
6	10	7	0	1,468
7	10	6	1	1,784
8	10	6	2	780
9	10	6	3	700

Nos. 6 and 7 test were only made to check the correctness of the tests Nos. 1 to 5, and are in perfect accordance with them. Test No. 8 contains the same proportions of magnesia and magnesium chloride as test No. 7, but double the quantity of water, and the result is a cement not half as strong as the latter; and still worse is No. 9 with 3 parts of water, notwithstanding the fact that the quantity of magnesium chloride is the same in each of the three samples. Sample No. 7 never shows any swelling or hair cracks, but the samples Nos. 8 and 9 are in this respect as bad if not worse than samples No. 4 and No. 5.

These results show that the water of the solution of magnesium chloride plays a very important part in these cements, and acts not simply as a solvent. This is further shown by the fact that a solution of magnesium chloride in absolute alcohol does not form any cement with magnesia, no matter how long it is in contact with it, as long as the moisture of the air is excluded.

Sorel considered his cement simply as an oxychloride of magnesium, but this compound, very probably, does not exist at all. All the samples I described contain a very considerable quantity of water, of which only a very small part is given off at $100^\circ C$; and even at $200^\circ C$. not more than 70 per cent. of the total water the cement contains is expelled. From this we have to conclude that the setting of Sorel's magnesia cement is one and the same process as the setting of the Portland cements, *i. e.*, assimilation of water, this process of assimilation evidently being facilitated by the presence of magnesium chloride.

According to this, we shall have to describe this cement as hydroxychloride of magnesium. Bender, to my knowledge, was the first to point this out. Bender evidently used a magnesium chloride solution containing about 50 per cent. $MgCl_2$ 6 aq., as the composition answered the formula $MgCl_2 + 5 MgO + 17 H_2O$. This cement lost 3 H_2O in the desiccator at ordinary temperature, 9 H_2O at $100^\circ C$, 11 H_2O at $180^\circ C$. On treating the cement with cold water, it lost $MgCl_2$, and the composition of the remainder answered the formula $MgCl_2 + 9 MgO + 24 H_2O$. Boiling water removes the magnesium chloride entirely, resulting in a cement of the formula 2 MgO , 3 H_2O , and Bender further adds that neither the treatment with cold nor with hot water has any destructive effect upon the agglomerated cement.

My experiments do not corroborate this statement, nor is it in accordance with the results of the experiments made on a large scale with Sorel's cement. It is perfectly correct that water extracts $MgCl_2$ from the cement, which assimilates a proportionate amount of water, but this reaction invariably destroys the agglomeration of the cement; still more so if boiling water be used. This effect, produced by the action of water, makes Sorel's cement utterly useless for outdoor purposes, where it would be exposed to the influence of atmospheric moisture, and on that score failed all experiments on a large scale. The Union Stone Company in Boston, U. S. A., used Sorel's cement for the manufacture of artificial stones and emery wheels, and, as far as I am aware, the artificial stones were a failure. How the emery wheels turned out is not stated, but I am afraid the results were not very gratifying, as my own experience showed that emery wheels made from Sorel's cement are rather dangerous in use. They may for some time run right enough, and work extremely well, but they suddenly burst without any apparent cause. These very serious drawbacks are sufficient explanation that Sorel's cement, in spite of its cheap price and other advantages, is very little used.

If, instead of the magnesium chloride, a substance could be found which would form an insoluble compound with magnesia and at the same time have the same active properties with regard to the hydration of the magnesia, all these drawbacks would at once cease to exist, and, no doubt, the magnesia cement would forthwith take its place as a cement of the first order, admirably adapted for the manufacture of artificial stones for building, ornamental, and a number of other purposes. Already Sorel hinted that magnesium chloride might be dispensed with and other compounds used instead, but at the same time he did not mention any compound better suited to the purpose than magnesium chloride. I experimented with chloride of potassium and chloride of sodium, both of which act in a similar way as the chloride of magnesium, but certainly with no better results. The chlorides of the alkaline earths do not answer at all, nor do any of the sulphates of the alkalies or alkaline earths. But there is a decided action by silicic acid, or such of the silicates which, being treated with hydrochloric acid, produce gelatinous silicic acid. I experimented with powdered flint, infusorial earth, hydrated silicic acid, and anhydrous silicic acid, the last two named produced from a solution of silicate of soda by addition of hydrochloric acid. The silicates I used were silicate of soda, silicate of magnesia, and silicate of lime. Powdered flint, as will be expected, showed extremely little, if any, action, although it had been most carefully incorporated to the magnesia; the cement it produced took considerable time in setting, and was only moderately strong. Infusorial earth gave considerably better results, the cement setting very quickly and showing considerable hardness and strength. Hydrosilicic acid acted so suddenly that it was past the maximum of its action before it was properly mixed with the magnesia. Precipitated anhydrous silicic acid proved the best of the series, producing after ten hours' setting a very hard and in every respect very strong cement of perfectly white color. Silicate of soda forms with magnesia a paste which very soon hardens, without, however, producing a cement of any remarkable properties. The silicates of magnesia and lime behave very much like the soda silicate, but take a longer time to set than the latter. Of the whole series, the precipitated anhydrous silicic acid showed to best effect, and was

further proceeded with. A series of experiments was made to ascertain the best proportion of magnesia and silicic acid:

No.	MgO.	SiO_2 .	Time for Setting, in Hours.	Tensile Strength per Inch Square.
10	100	5	32	211
11	100	7	24	313
12	100	10	15	780
13	100	15	14	1,300
14	100	22.5	12	302
15	100	30	19	510

To get reliable results it is necessary to incorporate the silicic acid with the magnesia as carefully as possible, otherwise the repetitions of one and the same test may nearly as widely differ in the figure representing the tensile strength as any two of the above tests differ from each other.

This shows that about 15 per cent. of silicic acid are required to give the best result as regards the strength of the cement. Test No. 14 was quicker in setting, but considerably weaker. But even No. 15, the strongest of the series, remains considerably behind the figures we found for the magnesium chloride cements; but on the other hand, these cements made with silicic acid are perfectly indifferent against water, cold or hot, and under no circumstances begin to swell after setting. But a difficulty in the practical use of these cements would be their very great liability to become inert so very soon after exposure to the atmosphere. Two or three hours' exposure I found quite sufficient to nearly annihilate the hydraulic properties of this cement mixture. This is certainly a very serious drawback, as in practical use it would mean a great deal of waste; but it can be overcome simply by mixing the silica magnesia cement with a solution of magnesium chloride instead of water. The cement thus formed sets in about ten hours, and forms an extremely hard mass; which in strength even surpasses Sorel's cement, without sharing the unwelcome properties of the latter. Water takes up magnesium chloride from this cement as from Sorel's, but no expansion is noticeable. Treatment with cold water is quite sufficient to extract all the magnesium chloride, the place of which in the cement is taken by water hydrating the magnesia.

The admixture of silicic acid with Sorel's magnesia cement makes the latter closely related to the hydraulic mortars as well as the Portland and Roman cement, as the formation of a hydraulic magnesium silicate in that mixture is beyond doubt. On treatment of this new cement, after setting, with hydrochloric acid, it slowly decomposes. The whole of the magnesia and about 30 per cent. of the total silicic acid contained in such a cement are in solution, the rest of the silicic acid appearing in the gelatinous state. The best proportions for the preparation of this new cement I found to be:

100 magnesia.
15 silicic acid.
90 magnesium chloride solution, 80 per cent.

This cement is of a tensile strength equal to 1,788 lb. per inch square, the most important part being the mixing of the magnesia and silicic acid, which must be done as carefully as possible. Absorption of carbonic acid previous to use to the extent of about two per cent. has scarcely any effect upon it; a larger proportion acts in precisely the same manner as in the other magnesia cements, and must be avoided.

The practical application of a magnesia cement free from the defects pointed out above will be very great indeed, owing to its cheapness, remarkably fine color and great agglomerating capacity, many times surpassing that of Portland cement. As far as my personal experience goes, magnesia cement is a material of the first order for the manufacture of artificial stones for ordinary building and ornamental purposes, for the manufacture of emery wheels, and for the production of artificial lithographic stones. Only in the first of these applications named can it be said to enter into competition with Portland cement, the other applications being altogether beyond the scope of the latter. Whether magnesia cement will ever be capable of competing with Portland cement in general concreting work and constructions under water I am hardly able to give an opinion yet, but it may interest you to hear that I employed it successfully for the construction of engine beds, the results also from an economical point of view being highly satisfactory.

The materials which can be utilized for the manufacture of artificial stones from magnesia cement are preferably such containing silica or silicates. Sand, crushed granite, porphyry, glass, Yorkshire and Cheshire sandstones, and the like answering very well. The quantity of cement to be used depends very little on the chemical nature of the filling-up material, but is very considerably influenced by the coarser or finer granulation of the materials used. The strengths such mixtures attain is, however, quite independent of the degree of granulation, as under all circumstances we are able to produce from any of the above filling-up materials with magnesia cement a composition very much stronger than the cement itself. This seems a very remarkable fact, and a few examples may serve to illustrate it. I used in the following series of experiments emery simply because this material is readily obtainable crushed to a number of standard sizes, the grains varying in size from $\frac{1}{4}$ of an inch (emery No. 6) to $\frac{1}{16}$ of an inch (emery No. 200 or emery flour). The samples were always tested one week after they had been made, as it was found that after this time they gain in four months about five per cent. only in strength.

This series clearly shows the remarkable fact above referred to, *i. e.*, that mixtures of magnesia cement and indifferent mineral materials produce compositions at least as strong as the cement itself, and eventually twice as strong. But this result is subject to certain conditions, the most important of which is that the cement mixture used must be such as to allow each particle of the filling-up material to be got perfectly coated with it, after which the mixture must remain of a rather moist, not dry and sticky, appearance. There are, of course, two ways of arriving at this end, the one being to use a rather thin flowing cement mixture to start

with, or to use a larger quantity of a drier cement mixture. Of these two ways, I found the first to give the better result. The strongest cement mixture I produced is No. 1, viz., 10 parts of magnesia and 6 of magnesium chloride solution; these proportions produce a very dry mixture, and you will see that in combination with emery it yields a composition very much inferior in tensile strength to a similar combination made with No. 3 cement, although the latter in its pure state is very much weaker than No. 1. Experiments Nos. 16, 17, and 18 all contain the same cement mixture, but you see how the strength is increased simply by using larger proportions of it, that is making the combined mixture of cement and emery moister. The importance of this point is still better illustrated by using the finer emery, 24 or 36. You will notice that the 20 per cent. compositions, Nos. 16, 20, and 23, show a great falling off in strength corresponding to the finer granulation of the emery, but in every instance the 40 per cent. compositions, Nos. 18, 22, and 25, show the same strength. By using more than 40 per cent. of the cement mixture no further increase in strength is obtained; on the contrary it begins to decrease, and at about 80 per cent. the combined mixtures show the same strength as the corresponding pure cement. Emery flour, however, forms the exception of the rule, as it reaches its maximum strength with 60 per cent. cement. It never attains the strength we could obtain with coarser material, but on the other hand we reach the minimum strength, that is the strength of the pure cement, only in using equal parts of cement and emery flour.

Cement No. 1 forming an exceedingly stiff paste, it is quite clear that, although it is about the strongest magnesia cement which can be produced, it will never give satisfactory results in combination with indifferent materials. Of course it might appear that its excessive stickiness by addition of water could be so reduced as to give it the required fluidity, but if you look at experiment No. 28, which represents the strongest compound I could obtain under these conditions, you will see, although it is much stronger than the corresponding experiment No. 19, still it remains considerably behind the strength of the pure cement. This might still be accounted for by deficient fluidity, and no doubt it is; but by adding more water, as in experiment No. 29, you see that the result shows the contrary of an improvement. This is evidently due to the detrimental influence of the water as shown by the experiments 8 and 9, and also by No. 30, which otherwise corresponds to No. 18.

No.	MgO,	MgCl ₂ sol., 80 per cent. sol.	Water.	Emery 16.	Emery 24.	Emery 36.	Emery flour.	Tensile strength, lb. per inch sq.
16	10	10	.....	100	.....	.....	.....	1,100
17	15	15	.....	100	.....	.....	.....	1,428
18	20	20	.....	100	.....	.....	.....	2,236
19	10	6	.....	100	.....	.....	.....	868
20	10	10	.....	.....	100	.....	.....	901
21	15	15	.....	.....	100	.....	.....	1,541
22	20	20	.....	.....	100	.....	.....	2,236
23	10	10	.....	.....	.....	100	.....	610
24	15	15	.....	.....	.....	100	.....	1,680
25	20	20	.....	.....	.....	100	.....	2,230
26	30	30	.....	.....	.....	.....	100	1,870
27	50	50	.....	.....	.....	.....	100	1,108
28	10	6	1	100	.....	.....	.....	1,303
29	10	6	100	100	.....	.....	.....	940
30	20	20	100	100	.....	.....	.....	1,360

Considering the great strength of compounds of magnesia cement, it will appear that it is very well adapted for the manufacture of emery wheels, and indeed it has been used for this purpose for some time; but such an emery wheel is scarcely safe enough in use, for reasons I pointed out before. If, however, to Sorel's magnesia cement the silica magnesia cement be substituted, the wheels produced are of remarkable toughness, and perhaps as safe as the emery wheels considered the safest of all, namely, those made with India rubber as cohesive matter. The proportion of cement in the magnesia emery wheels ought not to be less than 20 per cent. of the emery; it never exceeds 50 per cent. Of a somewhat similar nature is the use of this cement for the manufacture of millstones. The face of these stones can be made from emery with a backing of crushed flint. Such millstones are in hardness, lasting quality, and general efficiency very much superior to natural stones, especially for the grinding of very hard material. For corn grinding they are not so well adapted, though they are used very extensively for the shelling of rice.

The future of the magnesia cement seems, however, to lie in its application for the manufacture of artificial building stones, as very small percentages of the cement are required to form remarkably strong stones. Nearly any mineral material can be used for this purpose, and especially good results can be obtained with mixtures of sand and not too coarse pebble or gravel. The stones may be colored, or given an ornamental face backed by ordinary material; in this way stones are obtained which at very moderate cost resemble in appearance polished marble or granite. The most important question with regard to these stones is of course whether they will resist the influence of the atmosphere as well as a good natural building stone. As far as artificial stones from Sorel cement are concerned, this question must be answered in the negative; but stones made from the silica of magnesia cement withstood the influence of the atmosphere for over 12 months without showing the slightest sign of deterioration. Among the specimens I brought here to-night you will find some which have been exposed for a considerable period without in any way looking the worse for it.

A few experiments which I made with a view to produce artificial lithographic stones proved very successful, in so far as the stone I obtained behaved in practical use in every respect like the natural lithographic stones from the Bavarian quarries, but did not yield the same number of impressions as the latter. This difficulty, however, I consider not very difficult to overcome, as it merely seems to be a question of the absorbing qualities of the stone. The artificial production of these stones would be a matter of no small

commercial importance, as up to now the trade in lithographic stones is monopolized by the Bavarian quarry owners.

[NATURE.]

PHOTOGRAPHIC PERSPECTIVE AND THE USE OF ENLARGEMENT.

It is not uncommon to hear it remarked that photographs make hills look low, or that they make things look "such a long way off;" and that they do so in a great many cases is perfectly true.

In explanation of the apparent lowness of photographed mountains, I have heard it suggested that the eye judges horizontal and vertical distances by different standards, and this, too, is probably the case; but since there is a horizontal and a vertical in a picture as well as in nature, the eye ought to form similar judgments on both.

The true meaning of the appearances alluded to, though they admit of a most simple explanation, is not as generally understood as might be expected.

The fact is that they depend merely on perspective.

In elementary books on drawing there often appears a diagram in which imaginary threads are supposed to be stretched from every point of an object, through an upright sheet of glass, and to intersect in some point behind it. The trace of these threads on the glass will there form a picture of the object which is in true perspective, when viewed from the intersection of the threads; and if the proper amount of light, shade, and color be supposed to be added, this picture, to the single eye so placed, would be absolutely undistinguishable from the object itself.

But now suppose the eye is not at the place of intersection of the threads, but a certain distance farther off or nearer to the glass. It is evident that the apparent angular magnitude of every object in the picture is altered in the ratio of the distance of the intersection of the threads to the distance of the eye from the glass. But this is exactly what would be the case if, keeping the eye at the intersection of the threads, a new picture were formed on the glass either by altering the size of the real objects in this ratio, or their distance from the glass in the inverse ratio.

For instance, let the objects forming the picture be two towers, one say half a mile off and the other a mile, and suppose that the intersection of the threads is one foot behind the glass; to the eye placed at that distance the towers in the picture will subtend the same angle as they do in reality; but if the eye be moved a foot further from the glass, these angles will be halved, and the same picture will then fall on the retina as would be formed there were the eye one foot from the glass and the towers only half their actual size, or if they were removed to the distances of one mile and two miles respectively.

Thus by viewing the picture from the wrong distance, either the apparent size of the objects represented by it

is multiplied by ratio $\frac{\text{true distance}}{\text{wrong distance}}$, or their apparent distances by $\frac{\text{wrong distance}}{\text{true distance}}$.

Putting this in symbols, for the sake of simplicity and brevity, we have, if D = true distance of an object from the point of view, A = its real linear magnitude, F = distance at which the picture must be viewed in order to convey a correct impression of D and A . Then if d and a are the values corresponding to D and A when the picture is seen from the distance

f , we have $d = \frac{f}{F} D$ when A is judged correctly;

$a = \frac{F}{f} A$ when D is judged correctly. Of course both

A and D may be misjudged, but apparent and true distances in sizes are still connected by the relation

$$ad = AD.$$

In a photograph, F is the focal length of the lens with which it was taken, and f the distance at which it is looked at. Thus, if, as is generally the case with all moderate sized pictures, the focal length of the lens is less than the distance one would naturally hold the picture at for convenient view, the inevitable result is either that the apparent distances of the picture are

greater than the real ones in the proportion of $\frac{f}{F}$, or that the apparent sizes of the things represented in it

are reduced in the proportion $\frac{F}{f}$, or a combination of both these wrong impressions is produced.

Which of these effects or what combination of them is suggested depends much on the nature of the picture itself.

In interiors taken with a wide-angle, short-focused lens, distances are enormously exaggerated, while in landscapes it is generally the sizes of things which seem diminished.

As a rule, it may be said that objects which do not themselves suggest any scale will be made to look small, while those which do, such as men, houses, etc., will appear distant.

When $\frac{f}{F}$ is greater than unity, i. e., when the picture is viewed too near, the reverse of the above effects is seen; and as far as the perspective is concerned, the scene is being viewed through a telescope.

The magnifying power of a telescope is the focal length of the object-glass divided by the focal length of the eye-piece, or, in other words, the distance from the lens at which the image is formed divided by the distance from which it is viewed.

If the focal length of the eye-piece is the same as that of the object-glass, there is no magnification, and in the field of the telescope will be seen an exact reproduction of the natural view.

When, however, by shortening the focal length of the eye-piece, magnification is obtained, foreshortening

of all the distances in the ratio $\frac{F}{f}$ —naturally takes place.

This may be practically illustrated in rather a striking

ing way by looking from a railway bridge along a straight piece of line at an approaching train.

Supposing the train to be traveling at forty miles per hour, if the telescopic power be forty, the apparent rate of approach will be only one mile per hour.

From what has been said, it will be clear that just the same laws apply to photographic pictures (or any pictures in true perspective) as to telescopic images, and that there is only one distance at which they will convey a correct impression to the eye.

This being so, it is evident that any photograph taken with a lens of less than about a foot focal length must exaggerate all the distances, or make objects in the picture look smaller than they should, and the only remedy for this is to enlarge the picture until the right distance to view it from becomes also the convenient distance.

Even if this be done, however, there is still a tendency to view the picture too far off; for few lenses, except those for portraits, embrace an angle so small as to be taken in at a single glance, and people are naturally inclined to stand far enough from a picture to see the whole of it at once.

Still, a proper amount of enlargement offers the best means of making a photograph give a true idea of the scene which it represents; and this is especially true of the small pictures taken by so-called "detective" cameras, having lenses varying from four to six inches in focal length; and it is for this end, and not, in general, to enable more detail to be seen, that the enlarging process is most useful.

Of course, negatives for enlargement must be well enough defined to bear being examined from the focal distance of the lens which took them, or less than this (since detail is lost in the enlarging process), and many which would pass muster well enough when held a foot or more off will be found imperfect when looked at from the lesser distance.

In a subsequent article I will, if the editor permits, enter more fully on the subject of photographic definition and its limits, both as they depend on the nature of the various sensitive films and on the lenses by which the image is formed.

A. MALLOCK.

AN INCANDESCENT LAMP FACTORY IN THE NORTHWEST.

By W. FORMAN COLLINS.

AMONG the new and important industries of the Northwest, a section of the country that has had an unprecedented and remarkably rapid growth during the past few years, is the incandescent lamp factory recently started by the Standard Lamp Company, of Appleton, Wisconsin. The new company is strongly backed financially and the field for its operation is very extensive, as evinced by the large volume of business already being done by the new concern, although of comparatively recent organization.

The writer having been cordially invited to inspect the new lamp industry has embodied his observations during a pleasant visit there in the following, which, it is hoped, will prove of interest and possibly instructive to those not versed in the process of incandescent lamp manufacture.

The factory of the company is located on the Fox River, on the lower dam, and comprises three buildings, the largest of which is 150 × 80 and three stories high, the others being somewhat smaller and only two stories in height. In the main building is located the dynamo room, and it is worthy of notice here that this factory is entirely operated by water power, being, probably, the only lamp factory so operated in the country. Five dynamos are employed, two each of 150 volts and 250 lights capacity, of the Mayo pattern, direct current; two of 500 volts and 50 amperes, used for treating purposes; and an alternating current machine of 500 volts and 50 amperes capacity, which is of special design and has been imported from Paris, and used for a special and improved method of treating the 50 volt lamps.

The water at present utilized is 225 h. p., obtained from three Leffel water wheels, which are controlled by a new electrical regulating device, designed by Messrs. A. F. & E. L. Oppermann, the electricians of the company. This apparatus maintains the power constant within a variation of one per cent. under all changes in load and enables the greatest uniformity to be obtained in the product. Another noticeable feature is an Archimedean screw for forcing the mercury into the pumps, dispensing altogether with the vacuum power pump.

The carbonizing room occupies all the remaining portion of the lower floor and is fitted up with specially designed furnaces for the carbonizing of the filaments.

On the next floor is the glass room, in which the glass blowers are at work sealing in lamps and making pumps, etc. The pump room is also on this floor, and at present there are 120 pumps in operation. These are of a specially modified Sprengel type, adapted for obtaining the highest possible vacuum, and having several improvements over the ordinary Sprengel, being designed by Mr. W. H. Sauer, superintendent of the glass department, and whose efforts in this line are well known. The socketing and lamp base department is also on this floor.

The third floor is entirely devoted to the testing room, which is fitted up throughout with the necessary testing apparatus. For this department, Messrs. Queen & Co., of Philadelphia, are now engaged in manufacturing a new pattern photometer of the most delicate sensibility to meet the requirements of the constantly increasing business.

The treating department is provided for in the larger of the two other buildings and occupies both floors. This process is of a secret nature, but as the writer was courteously permitted to inspect this work, he had an opportunity to notice the extreme care and precision with which every portion of the work, down to the most minute details, is carried out, and he can say from practical demonstration that the toughness and homogeneity obtained by this process must necessarily be conducive to long life and high efficiency. Ten sets of treating apparatus are employed in this department and it is remarkable with what dispatch and facility the work is accomplished under this system. The greatest care has been taken to prevent danger from fire, and should one break out it will be met with an efficient system of grenades and portable fire engines.

The other two-story building, referred to above, is