THE FAHNEHJELM WATER GAS INCANDESCENT LIGHT.*

By R. W. RAYMOND, New York City.

THE idea of obtaining light from incandescent solids is not new; nor is it new to make such bodies incandescent by holding them in a heating flame. But the successful combination of the right substance and form of the body to be heated with the right kind of flame, and the right means of adjustment, has not, to my knowledge, been accomplished heretofore; and it seems to me that the water-gas incandescent light of Mr. Otto Fahnehjelm, of Sweden, in which these objects appear to have been secured, is destined to become both famous and useful.

The first fact upon which this invention is based is the intense temperature of the flame of water-gas. The combustion of this gas through an ordinary coal-gas burner, without blast or aid of any kind, will melt platinum wire.†

The next important basis of the invention is the form of the incandescent body. This is shown in the accompanying cut, which represents an ordinary fan-tail gas burner, fitted with the necessary apparatus for producing the new incandescent light. A frame, movable by means of a screw up and down along the burner, carries at its two extremities sockets to receive two iron wire standards, which carry a curved back, provided with two rows of long teeth. By turning the screw, these teeth can be brought as near the tip of the burner as may be desired. They are composed of magnesia, which has been first baked at a high temperature, then ground, and then moulded under high pressure, and with some agglutinating material, such as starch. The flat flame of the water-gas passes up between the two rows of vertical teeth, which thus receive its greatest heat, and do not come into contact with its comparatively cooler interior. They become immediately and beautifully luminous, with a perfectly white light, which does not, like gas or candle light, change the daylight appearance of colors, and which can even be used for photographing. It is steadier than the incandescent electric. The flickering of the gas flame (which is non-luminous, and, when the comb is glowing, quite invisible) does not at all affect the steadiness of the light. If the gas is blown out, or if, by the use of a cock without a stop, it is turned off and then unwittingly on again, no evil results can follow in this case; for the comb goes on glowing for several seconds, and the gas consequently relights itself.

The magnesia teeth have before use the appearance of

BURNER FOR WATER GAS INCANDESCENT LIGHT.

starch. When thoroughly well prepared, they should possess considerable strength. The best that have been made thus far, I believe, would sustain eight ounces avoirdupois hung from the middle of the needle which was laid across supports one inch apart. Since the diameter is less than $\frac{1}{16}$ of an inch, this indicates a good degree of strength. The needles are held in a composition of plaster of Paris, which fills the curved back of the comb. This back, like the side wires, is of iron; and the whole comb, with its side wires, costs about three cents.

Apart from accidental breakage, such a comb endures from 80 to 150 hours incandescence before it must be removed. The first effect of the high white heat upon the needles is to make them translucent, like porcelain. Probably this change is really a condensation, fusing into a continuous mass what had previously been but a compressed aggregate of particles. The result is a gradual shortening of the needles, so that after about 15 hours it is necessary to turn the screw, and bring the comb down toward the flame. This process is repeated from time to time, until at last the needles have become so short that the iron back would be in danger from the flame if they were brought fairly into it. Then the comb must be taken out, and a new long-toothed one substituted.

Exact photometric and economic tests have yet to be made under American conditions, and for water-gas produced by different processes. Speaking in a general way, I should say that the quantity of pure water-gas required to produce a given amount of light by this system is about four-fifths (in volume) the quantity of carbureted water-gas, like the Tessie gas of the Municipal Company of New York, required to give the same amount of light. The cost of the non-carbureted water-gas is, of course, much smaller. It can be sold to large profit for 50 cents per thousand cubic feet.

We have then in this invention, a light which is actually much cheaper than ordinary gas light, while in quality it equals, and in steadiness, uniformity, and simplicity of management far surpasses, the electric incandescent light.

ON THE REAL VALUE OF LUBRICANTS, AND ON THE CORRECT METHOD OF COMPARING PRICES.*

By ROBERT H. THURSTON, M. Am. Soc. C. E.

THE real value of any lubricant is a quantity which seldom has any direct relation to its market price, and depends not only upon the intrinsic qualities of the lubricant itself, but upon the economical conditions under which it is to be used. It is dependent to a greater extent upon the magnitude and cost of power than upon the expense of its purchase or preparation for use by the consumer. The correct method of comparing prices, from the user's standpoint, is not one involving merely a determination of the properties of the material as a reducer of friction, and the true value of the oil is not simply proportional to its endurance and its power of reducing lost work; it includes a study of the method by which it reduces the total expenses of lessening the friction, and the extent to which the total expense for power is reduced by such reduction of work wasted by friction. The usual systems of comparison are entirely wrong, and are only justifiable by the fact that hitherto it has been impracticable to obtain the data required for the establishment of a correct method. This difficulty no longer exists, and every intelligent purchaser of lubricants is coming to see that he may often effect enormous economies by the careful study of the variation of the total cost of lubricant and of waste power.

The total cost of the lost work in machinery includes two distinct items—the cost of lubricant and the cost of doing the work of overcoming friction of the lubricated surfaces. Of these, the latter is usually enormously the greater, and it is at once seen that a saving in cost of lubricant is of slight importance in comparison with a saving of equal proportion in the reduction of the cost of the power demanded to overcome friction, and which is thus wasted. A dollar expended in the substitution of good oil for one of lower grade may save a hundred by reduction of the waste of fuel and other expenses of power-production. Such expenses include fuel, salaries, interest on capital invested in motive power, taxes, and insurance on the driving machinery, boilers, and building, and other minor costs, which every proprietor can readily estimate with fairly accurate figures, if not with perfect satisfaction to himself. The total cost of steam power thus foots up to about \$100 per horse power per annum in New York city, and to a minimum of, perhaps, \$50 under more favorable conditions. Water power often costs considerably less, although the cost of dams, reservoirs, and machinery is large.

If, in any case, we call the total expense per hour K , the cost of the lubricant on the journal k , the quantity used q , the total cost of power per horse power per hour k' , and the amount of power used in overcoming friction of lubricated surfaces U , the total expense chargeable to "lost work" will be

$$K = kq + k'U \quad (1.)$$

The work done in overcoming friction U is proportional to the mean pressure on the lubricated surfaces P , to the speed of relative motion of rubbing surfaces V , to the time taken for comparison t , and to the magnitude of the coefficient of friction f . Thus we may write

$$K = kq + b f \quad (2.)$$

in which b is a constant, the value of which, $k' P V t$, is easily ascertained in any given case, and the calculation of the cost of friction is then readily made.

Where two oils are to be compared, to determine the economy to be secured by the substitution of the one for the other, the values of q and of f , and the cost per gallon, k , of each will be known, and the two values of K thus obtained will exhibit the relative economy of their use. If K is the same for the two, it is a matter of indifference which is used; if K is greater in one case than in the other, that oil is the more economical which gives the lower value, even though it may cost more per gallon, and may require to be more freely used than the other. Thus, suppose, for the two cases we have

$$K_1 = k_1 q_1 + b f_1; \quad K_2 = k_2 q_2 + b f_2$$

If these two values of K were equal, $K_1 = K_2$, and the gain by purchasing the second oil is just compensated by the loss due to increased demand for power to overcome the increased friction, and

$$k_1 q_1 - k_2 q_2 = b (f_1 - f_2) \quad (3.)$$

$$k_2 = \frac{k_1 q_1 + b (f_1 - f_2)}{q_2} \quad (4.)$$

Any price paid for the second oil, delivered on the journal, less than k_2 , gives a profit; any greater price produces loss. This last equation is thus a criterion by which to determine what price, k_2 , may be paid for any oil proposed to be substituted for the first oil, costing $k_1 q_1$ per hour.

Where the same quantity is used of each, as may be the case frequently, $q_2 = q_1$, and

$$k_2 = \frac{b}{q_1} (f_1 - f_2) + k_1 \quad (5.)$$

The question sometimes arises whether it is better to use a larger quantity of a certain oil already in use; in this case, $k_2 = k_1$, and the quantity allowable without loss is

$$q_2 = \frac{b}{k_1} (f_1 - f_2) + q_1 \quad (6.)$$

Where the relative endurance, and the relative values of the coefficient of friction, are determined by experiments made under the conditions of proposed use, if e and h represent the two ratios, since the quantity used will be inversely as the endurance, and the power wasted will be directly as the coefficients of friction,

$$k_2 = e k_1 + b e f_1 \frac{1-h}{q_1} \quad (7.)$$

and this expression becomes the criterion of values.

Instead of taking the time as one hour and the unit of the power as the horse power, it may be convenient to adopt other units. Thus on railroads the costs

are measured by the cost of oil and of power per train mile, and

$$K = kq + df \quad (8.)$$

in which q is the quantity of oil used per mile, and d f is the cost of power for the same distance. Also, as a criterion,

$$k_1 q_1 - k_2 q_2 = d (f_2 - f_1); \quad k_2 = \frac{k_1 q_1 + d (f_1 - f_2)}{q_2} \quad (9.)$$

In illustration of the application of these principles, take the following cases:

(1.) The proprietor of a large machine shop informs me that he finds the total expense of power to be nearly \$100 per horse power per annum, of which power one-half is estimated to be expended in doing work wasted in friction; that he uses 0.02 gallon per hour of good lubricants, costing an average of \$0.50 per gallon. The mean coefficient of friction is judged to be about 0.05. The value of b (eq. 2) is found to be 0.6 horse power, or 30 for 50 horse power; then

$$K_1 = 0.01 + 1.50 = \$1.51.$$

Suppose it be proposed to substitute for the oil in use one which costs but \$0.25 per gallon, and of which 0.03 is required per hour, and that the coefficient of friction with the cheaper oil is $f_2 = 0.06$; then

$$K_2 = 0.0075 + 1.80 = \$1.80\frac{3}{4},$$

and a gain of one-quarter of a cent per hour, or \$7.50 per year, is effected at the expense of a loss in cost of power of 30 cents an hour, or \$900 a year, and a net loss of \$892.50.

(2.) A cotton mill, using 200 horse power, in work of overcoming friction of lubricated surfaces, uses 0.7 gallon of oil per hour, at \$0.70 per gallon; it is proposed to substitute an oil costing \$0.40, and of which one gallon per hour will be required to do the work, while the coefficient of friction will rise from an average of 0.10 to 0.12. Taking b at 60, as before:

$$K_1 = 0.49 + 12.00 = \$12.49;$$

$$K_2 = 0.40 + 14.40 = \$14.80.$$

A gain in expense for oil amounting to 9 cents per hour, or \$270 per year, produces a loss in cost of power of \$2.40 per hour, or \$7,200 per year, assuming 3,000 working hours per annum. The net loss is \$6,930, i. e., nearly 30 times the profit on the oil account. This is not an unusual or an extraordinary case, as matters are now going on in the business.

(3.) A railroad train requires one cent's worth of oil per mile, and costs 10 cents per mile for power expended in friction, using a good oil, costing 50 cents per gallon, at the rate of 0.02 gallon per mile, with a mean coefficient of friction of 1 per cent. It is proposed to change, using an oil costing but 25 cents, at the rate of 0.03 gallon per mile, and obtaining a co-efficient of $f = 0.015$; then

$$df_1 = 0.10; \quad d = 10 \text{ (eq. 8);}$$

$$K_1 = 0.1 + 0.10 = \$0.11;$$

$$K_2 = 0.305 + 0.15 = \$0.15.$$

In this case, a gain of one-quarter of a cent per train mile in cost of oil brings about a loss of 4 cents—sixteen times as much—in increased train resistance.

Using the quotations given as criteria of values (eq. 4, 6, 9), we find the estimated value of k_2 to be, in the three cases given, respectively: —\$19, —\$2, and + 16½ cents, nearly, for the cases as taken. That is to say, the proprietor of the machine shop will lose \$19, nearly, on every gallon of the proposed oil that he may use; the owners of the cotton-mill will lose about \$2 on every gallon of inferior oil that they may purchase; while the railroad will lose money, unless it can get the second oil for 16½ cents.

But suppose, in further illustration, it is found possible, by increasing the supply of oil in the case of the machine shop, to reduce the mean coefficient of friction to 0.02, by using four times as much of the cheaper oil as was at first thought advisable. Applying our criterion to the case, we get (eq. 4):

$$k_2 = 0.03 + 0.60 = \$0.63;$$

and a gain is effected of nearly two-thirds the original cost of lubrication. An expenditure of \$60 gives a profit of about fifty times that amount.

It must not be assumed that these figures are more than rough approximations to fact; for it is difficult to obtain exact values of the quantities involved, and especially of the true mean value of f ; but they are sufficiently correct to answer as illustrations of the principles involved, and are near enough to the truth to give a fair idea of the magnitude of the losses which are each day met in consequence of the practice of the system of false economy now generally practiced in the purchase of lubricants.

The values assumed for the coefficients of friction are probably fairly representative of those found in common practice. The experiments made by the writer show that, under ordinary conditions of every day practice, the value for mechanism working under as light pressures as are met with in spinning frames, for example, different oils will give values varying from 1.10 to 0.25; under the usual pressures of heavy mill shafting, the figures range from 0.5 to 0.16; with pressures of greater intensity, such as are met in the steam engine and under railroad axle bearings, it often varies, using different lubricants, from about 0.01 up to 0.025, the first value being given by the best oils and the second by heavy greases. Under the exceptionally high pressures and at the speed of rubbing reached on the crank pins of some steam engines (500 to 1,000 pounds per square inch; 35 to 70 kgs. per sq. cm.), f may fall to one-half the last given values. In endurance, the same variations are met with. The endurance decreases as pressures increase, and is twice as great with the best oils as with others of good reputation. The market prices of oils have no relation to these relations of quality. The best oils for any given purpose may be either more costly or cheaper than others less well fitted for the work. In some cases prices are made in the most arbitrary manner.* Spermin, lard, olive, and some few standard grades of mineral oils probably have fair and well settled values; as a rule, however,

* Read at the New York Meeting of the American Institute of Mining Engineers, February, 1885.

† Mr. Otto Fahnehjelm, the inventor, who was present at the reading of this paper, demonstrated the truth of this statement experimentally before the audience.

* Read before the American Society of Civil Engineers, Jan. 7, 1885.

the price of a mineral or of a mixed oil is no guide to selection.

Should time permit and statistics prove to be attainable, the writer will endeavor to develop this subject more completely.

THE PROCESS OF BRONZE CASTING AS APPLIED TO SCULPTURE.

THE *cire perdue* process of bronze casting was the subject of a recent Royal Academy lecture by Mr. E. J. Boehm, R. A. The practical working of this process of casting the matrix from a wax model which is melted out was illustrated by the exhibit of a bronze bust still surrounded by the runners, air vents, and gutters, and also of the plaster of Paris matrix in which it was cast.

In his introductory observations Mr. Boehm gave a brief historical sketch of the process of bronze casting, in order to show that the *cire perdue* process was the oldest mode of the art. Long disused, it now bids fair to supersede the present imperfect way of making art castings, if sculptors and founders would take the trouble to carry it out.

A process analogous to *le cire perdue* was practiced even in prehistoric times, the old bronze weapons appear to have been carved in soft wood, which was covered with clay and fired.

A similar method of casting natural subjects protected by a fireproof casing was practiced by the Egyptians, the Japanese, and the modern Neapolitans. In early examples of the Egyptian, Greek, Etruscan, and some Roman works were found parts of a core of terra cotta still remaining in the bronze objects, showing that a similar process was adopted, and there was no doubt that the fifteen hundred bronze statues said to have been executed by Lysippos were by the same process.

Cellini, in his delightful autobiography, tells us that he adopted the same process for casting the Perseus at Florence, but the means now adopted were simpler and safer than that he devised.

Mr. Boehm proceeded to describe the present method, as follows:

The model in clay being finished and reproduced in plaster of Paris, a mould is made over the reproduction, technically called a piece mould, out of which a cast is made in wax, quite hollow, and about the thickness of $\frac{1}{8}$ inch. This having been done, and the seams on the surface of this wax caused by the juncture of the pieces of the mould being taken off, and all requisite and necessary retouching and corrections being made, the founder commences to fix on the runners, vents, and gutters, preparatory to making the fireproof mould over the object; and for this purpose he has prepared a number of sticks of wax, similar to that used for the cast. A great deal of skill is required for this operation, and the success of the cast depends greatly on the manner in which these sticks of wax are put on; which eventually are to become hollow, and act as channels for the escape of the wax from the mould during the firing, for conveying the molten metal throughout the mould, and for the air vents through which the air and gases are to escape, driven before the molten metal during the casting. One of the larger of these sticks of wax of which I have just spoken is selected, and the moulder having decided as to the best part of the wax model for attaching the main channel to, slightly heats the end of the stick of wax and applies it to the part, making it fast by passing a small iron or steel modeling tool, which he has heated for the purpose, round the juncture in order to thoroughly secure the joint. (This is the piece which starts out of the center of the back of the head of bust.)

The operation is repeated in precisely the same manner with regard to the other four large conduits, which are all joined carefully to the extremity of the first stone. He then adds the smaller ones, taking care that they shall all take a downward direction, so that no stoppage in the flow of the metal shall take place during the casting.

These conduits placed, the moulder is able to judge of the best points at which to fix the air vents; and he takes care to arrange them in such a manner that they shall not come in contact with the runners just finished, but that they shall readily conduct the air which is driven from the mould by the metal which takes its place as it escapes. The drains are now placed, and the same care is taken in their placing as has been observed with regard to the other tubes; and that they shall thoroughly fulfill their function, they must be quite straight toward the direction of their exit, and be free from all complication. A round funnel is now made, either in wax or paper dipped in melted wax, which is attached to the runners at their junction.

The next operation is to prepare for the "core." In order to provide for the escape of the gases which are generated in the core, which is of a porous nature, during the firing of the mould, to destroy the wax, two smooth iron tubes, well greased, are inserted into the wax, so that one end of each penetrates into the middle of the hollow in the wax model, and the longer end stands out on a level with the top of the runners where the funnel joins.

In Italy an automatic process is frequently employed for making the core of small objects simultaneously with the mould for works of the size of the model before us; and to give you an idea of the principle of it, I have prepared this small model in glass, the working of which I will show you at its proper time; but first of all I must proceed with a short description of the further preparation of the model for the mould and "core."

Iron nails, like those on the table, are slightly heated, and thrust through the wax until the one-half only projects on the outside of the cast and the pointed end penetrates into the inside. The heat of the nail so inserted slightly melts the wax all around it, which when set holds it firmly in its place. These nails having been placed in the parts least susceptible to damage, and the easiest repaired should any occur, the whole model is immersed in a tank of cold water, through which there is a constant flow of fresh water; the object of this being to insure against the settlement of any sediment from the water on any part of the wax, which might cause injury to the mould in firing. The model is left thus for a few hours, and when the wax is thoroughly hard and brittle it is carefully taken out, and is placed on a table or bench at a convenient height from the ground. While the water which still remains on the surface and in the hollows of the wax

drains off, or is removed by an assistant with a small brush or sponge, the moulder prepares his composition for making the mould; this is composed of plaster of Paris and brickdust mixed with water, in precisely the same manner in which plaster of Paris is mixed for moulding objects from clay. By this time the model is ready to receive the mould, and the moulder, with the assistance of help he can trust, commences to lay on the composition with a fine and soft brush, taking care to well fill all the crevices and hollows. In this manner a thin coating having been laid all over the surface of the wax, the whole, as it stands, is lifted three or four inches from the table on which it stands, and at such places as may be deemed necessary pieces of brick are placed under it, upon which it may rest raised from the table. The next thing to be done is to build a wall all round the object, at such a distance from it as the moulder will decide. This wall is smeared all over with clay, in order to render it entirely water-tight. A fresh mixing of the composition is made, but this time some that has been used before and has been thoroughly well burnt is well ground and added. This new mixing is poured gently into the space between the wall which surrounds the mould and the mould itself, and as the liquid composition rises it will penetrate throughout the interior of the wax within the mould, simultaneously with the outside setting as it rises round the points of the nails and finding its exit with its level on the outside through the hollow tubes, which you will remember were inserted for the purpose of forming gas escapes from the "core." It is very important that the "core" should be composed of exactly the same proportions as the outside mould, and it is here where the automatic system of forming it is so valuable.

Firing is the next process, to expel the wax from the mould. The block is placed upon a brickwork stage about two feet from the floor, and round it a furnace of firebricks is constructed, two chimneys being placed on the runners, and the escape vents communicating with the outer air. Round this furnace a second one is built, which is filled up with charcoal and coke. The fire is then lighted, and allowed to burn gradually at first, and increased slowly until the block within is thoroughly baked throughout, so that it has been completely heated to its very center. After a few hours, the wax flows and escapes through the drains, which were connected with the outer air by iron tubes passing through the furnaces, at the same time that the chimneys were placed over the "runners" and air vents at the time of building the first furnace. These outlets communicate with receptacles into which the wax flows. When the flow of wax ceases, care is taken to close the openings of these tubes, to prevent the entrance of the air into the interior of the mould, which would probably ruin the whole work. The fire is kept steadily burning, and the founder watches the chimneys which protrude through the top of the furnace, and which I have already said were attached to the head of the runners and air vents. After several hours' firing, puffs of blue smoke are seen to issue from the chimneys, which is a sign that the heat has been sufficient to evaporate any wax which may have been absorbed by the mould after its main bulk had run out through the drains. Still a few more hours, and the smoke becomes of a reddish color, and is succeeded by a vapor. The wax is now entirely destroyed. The fire is still increased to insure disappearance of all moisture from the mould, and from time to time the founder applies a cold polished steel plate or a piece of ordinary looking-glass to the orifice of the chimneys, through which he is able to detect the slightest indication of moisture still remaining. Being satisfied that the mould is thoroughly free from all moisture, the fire is covered up and allowed to burn itself out gradually. As soon as the fire is extinguished, the outer wall of the furnace is thrown down, and a few of the bricks of the inner wall are also removed to hasten the cooling of the block within. By degrees the whole of this wall is removed and the block is allowed to cool slowly, for sudden changes of temperature would, in all probability, cause the mould to crack, and the whole work would be defective.

I made reference to the use of iron nails being pressed through the wax. Until the block was submitted to the action of the fire, it was a solid mass; but now, since the wax has disappeared, the "core" has become isolated, and now is only kept in its place by the points of the nails, round which, during its formation, it has set, and they in their turn are kept stationary by the outside mould, which set round the portion which projected on the outside of the wax at the same time.

When the block was placed ready for firing, it presented a comparatively hard surface; but now it has undergone the great heat of the firing it has become extremely pliable, and is easily damaged. Directly the mould is sufficiently cool, it is carefully bound with iron hoops, and lowered into a pit which has been dug to receive it; and ordinary sand or moulding earth is pressed with the greatest care all round it until it is entirely buried, and only the mouth of the conduits and the air vents are visible. This precaution is necessary to avoid accidents occurring from the expansion of air, and the pressure of gas caused by the flowing of the fused metal through the mould.

Round the opening of the vents and air channels a basin-shaped hollow is scooped out in the block; the funnel of the runners is closed to prevent the current of air through the mould until the metal is ready to be poured. All is now ready for casting. In order to calculate the amount of metal required for casting a group, the wax model, prepared as it was with its tubes, which were solid in wax, but which have now become hollow in the mould, was weighed, and according to its weight a certain percentage on the whole over and above the weight is added, to allow for the difference in the specific gravity existing between wax and bronze; and for the runners, vents, and drains, which all become bronze by the flowing of the metal through the mould, and its surplus returning to its level through the vents.

The metal is poured gently into the mould, the stopper from the funnel over the runners having been removed; and now is the anxious moment for the founder, who listens attentively for the slightest noise in the mould, which is a sure sign of non-success. The metal soon solidifies, and in a very short time is cool enough to allow of the block being broken up. This is easily done; for by this time it has become so soft that it can almost be removed with the fingers. An unprac-

ticed eye, even when the mould is entirely removed, can hardly detect whether or not the cast is really successful, encumbered as it is by the network of solid rods of bronze, which were formerly the tubes for conveying the metal into the mould, and the air, wax, and gas from it; and, in addition, there is a white crust left from the surface of the mould still adhering to the object itself.

The runners, vents, and drains are sawn off, the nails withdrawn, the core picked out, and the object is placed in a bath of water and sulphuric acid for several hours, and when it is taken out, it is vigorously scrubbed with hard brushes, rinsed in clean water, and allowed to dry. The holes left by the nails are stopped, and all traces of the joints of the vents and runners are effaced, and the cast is then ready to receive its patina, or artificial coloring in imitation of that produced by oxidation.

As the patina of a bronze is quite a question of taste, and is obtainable by an endless variety of means, according to the effects required, I prefer to dismiss the subject, and I am obliged to refrain from entering into the very elaborate subject of alloys of copper for bronze, and their melting and blending together, rather than enter upon them in too slight a manner, and time would not permit of my doing otherwise tonight.

In conclusion, I need not point out the great advantages which the *cire perdue* process has over bronze castings from moulds made in sand, and I am sorry to say sometimes in woolly loam on plaster models; which system requires the removal of not only the seams left by the joints of the piece mould, but more or less of the entire surface, in order to produce an even texture throughout. Could and would the sculptor do that himself, and give with the chasing tool that character so peculiarly beautiful in the metal work of the Greeks, and many bronzes of the Renaissance, then any method of reproducing would be acceptable and justifiable; but this is scarcely ever achieved. And in the hands of the usual metal chaser the result is generally disastrous.

We can only hope that the art of bronze casting will eventually meet with the encouragement and result which will elevate it from the commercial iron foundry to an art, and not a brainless trade only.

[AMERICAN ARCHITECT.]

HINTS ON PLASTERING, MORTARS, ETC.

It is not an uncommon complaint from proprietors of dwellings, hotels, office buildings, etc., heated by furnaces or by steam, that in a few years after being constructed the interior finish of brick walls commences to scale off, if painted, or the entire plastering comes loose from the walls in patches four or five yards in extent, and seemingly rotten, the cementing qualities all gone. This scaling off of the paint or falling off of the plastering being confined to the brick walls only, the stud partitions, lathed ceilings, and furred brick walls remaining good, there is no room for doubt but that a very large proportion of the mortars used in the construction of modern brick walls, as well as that employed for plastering, is improperly proportioned, badly mixed, and too quickly used, and hence possesses only in a low degree those valuable properties of strong coherency of their component parts and the quality of adhesiveness.

The responsibility for the damages to buildings arising from the employment of poor qualities of mortar should often rest as heavily upon the architect as upon the contractor, the bricklayer, or the plasterer. In the vast area covered by the United States, there are so many different kinds of mortar employed for the purposes of constructing and finishing buildings, that it would be impossible to formulate a rule which would result in producing a good mortar from the materials found in the various sections of the country. But it is the business of the architect to thoroughly familiarize himself with the materials found in the section covered by his practice and used for mortar making. After becoming acquainted with the materials, the architect should specify the qualities and proportions of lime and sand to be employed, and the manner of mixing, and the age of the mortar before use.

As the defects which have been mentioned are confined to the interior finish of brick walls, and do not affect ceilings or other plastering work not in actual contact with brickwork, it is evident that we must look farther than the plastering for the cause of the damage. Experience has clearly demonstrated that mortar, of whatever kind, is greatly affected, either for good or for evil, by the nature and the quality of the bricks or stones with which it is brought in contact, and, consequently, in order to obtain the best constructive results the material over which the mortar is applied should receive proper attention. An experiment made by the writer, with a view to demonstrating the action of the ordinary mixture of cement and lime mortar used by bricklayers in the city of Washington in foundation work on the common varieties of bricks, showed that the strength of the same mortar greatly varied with different kinds of bricks, being lowest with those of greatest porosity. Two hard-burned arch bricks, each having a surface measurement on their mortar faces of 7.75x3.75 inches, separated under a pull of 43 pounds to the square inch. Two red bricks measuring 3.25x4.06 inches separated under a pull of 34 pounds to the square inch. Two salmon (soft) bricks measuring 3.75x4.3 inches separated under a pull of 15 pounds to the square inch. The bricks had lain together for about six weeks, and the joints of mortar between them were one-half inch thick, the same as those used for ordinary brickwork. The bricks were good hand-made stock, moulded from moderately strong clay, but if they had been manufactured from meager or weak clay, the results would have been lower than those which have been given. The cementing qualities of mortar, consequently, not only depend upon the kind of bricks to which it is applied, but also upon the nature of the clay from which the bricks are made, and also upon the manner in which they are moulded. Bricks made from tempered clay and solidly moulded increase the cementing qualities of mortar, but bricks made by the so-called dry-clay machine process lessen the strength of the mortar, as the first class of bricks are close and compact, and the latter are commonly open and porous. The poor results obtained with "salmon" or soft bricks were unquestionably on account of their great porosity, as during the setting of