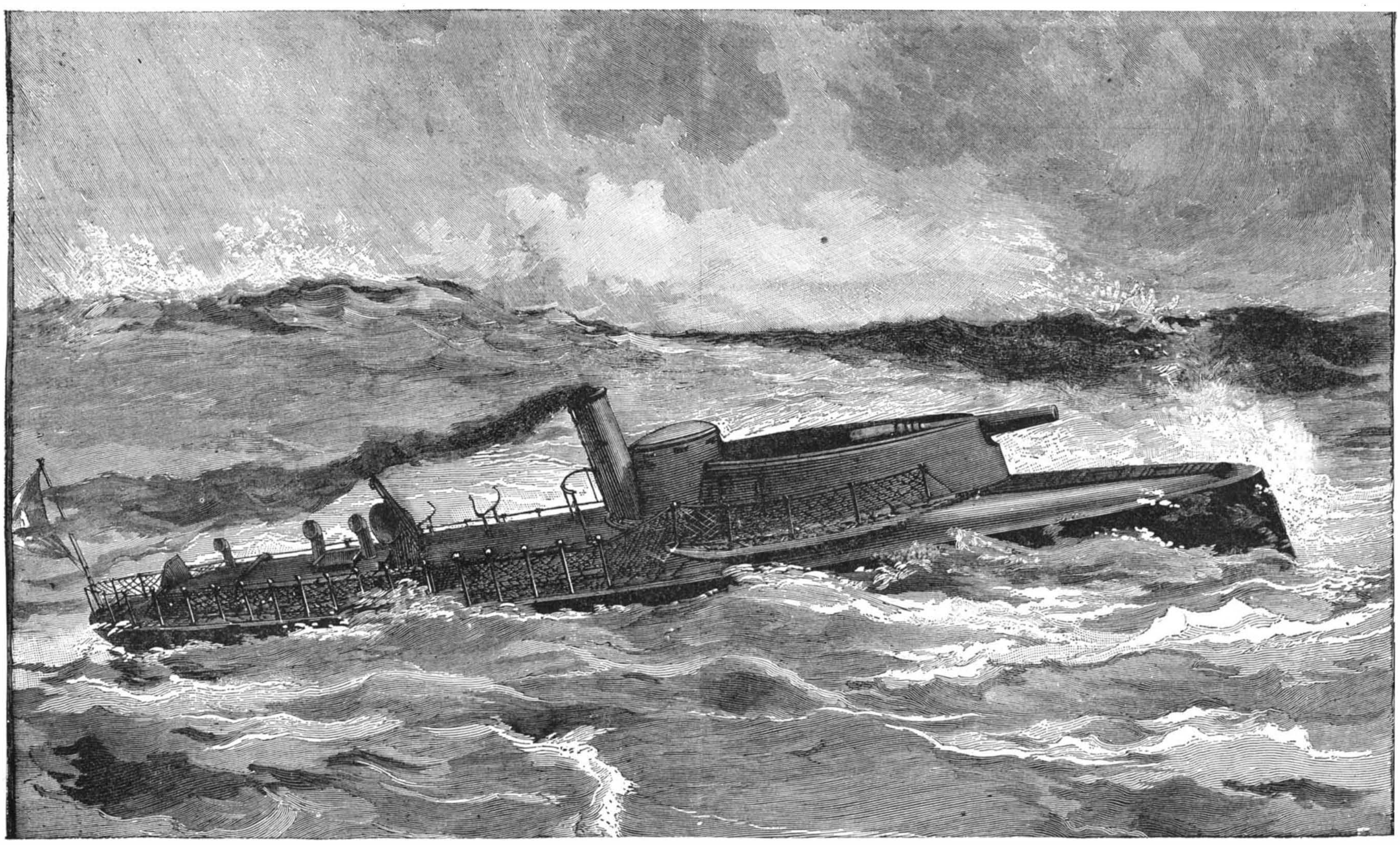
SCIENTIFIC AMERICAN
SUPPLEMENT No. 578

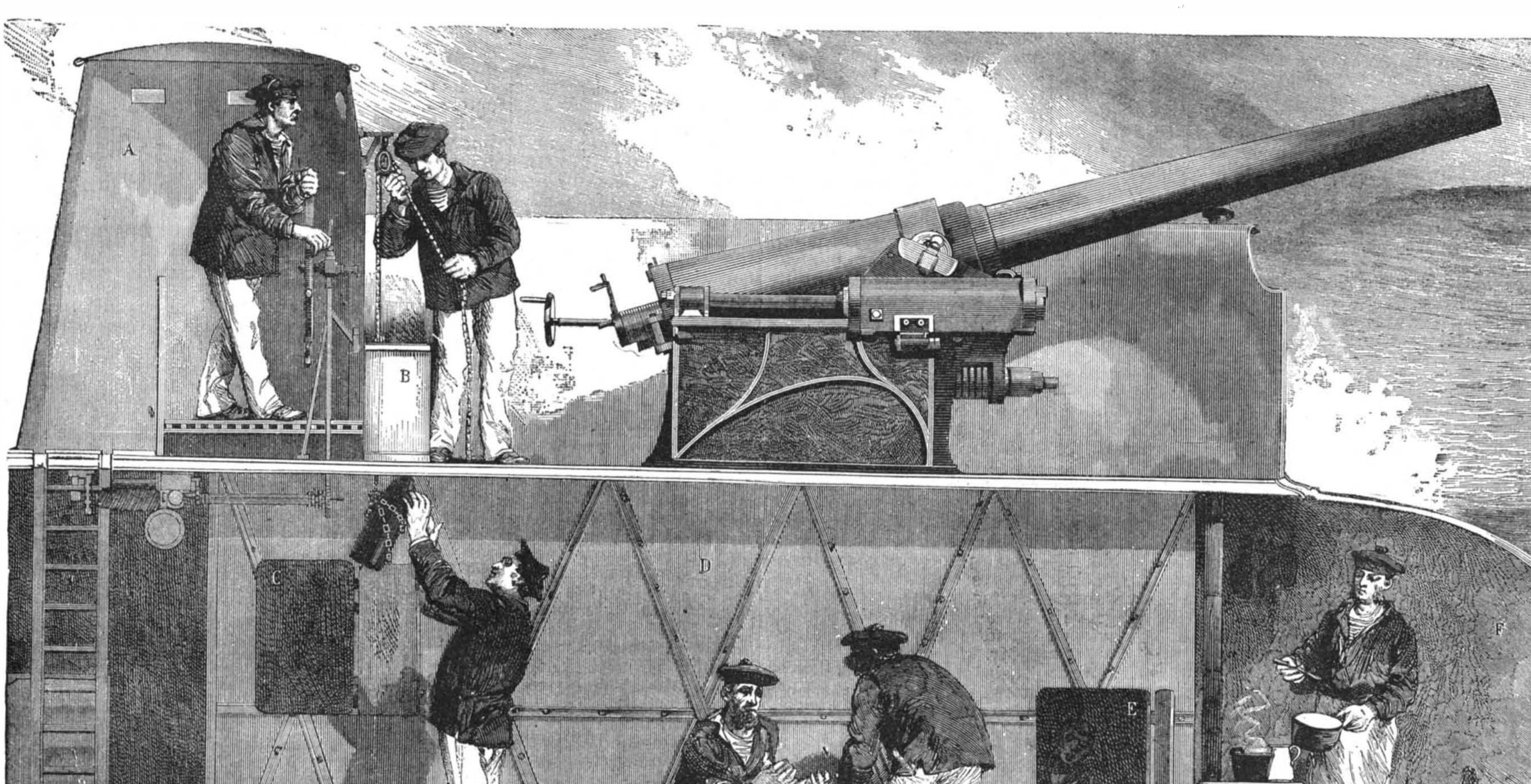
Scientific American Supplement, Vol. XXIII., No. 578.
Scientific American, established 1845.

NEW YORK, JANUARY 29, 1887.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



THE NEW FRENCH GUNBOAT GABRIEL CHARMES.



A. The Pilot House. B. Well for Passage of Ammunition. C. Door Opening into Projectile Magazine. D. Passageway for Handling the Ammunition. E. Door Opening into Cartridge Magazine. F. Kitchen.

TRANSVERSE SECTION SHOWING THE INTERIOR ARRANGEMENT AND THE LOCATION OF THE ARTILLERY.

THE FRENCH GUNBOAT GABRIEL CHARMES.

It will be remembered what a sensation there was, two years ago, on the publication of a work by Mr. Gabriel Charmes upon the transformation of our navy. According to Mr. Charmes, ironclad ships had served their time, and these heavy and costly craft were to disappear, and the navy of the future was to consist only of torpedo boats, non-curaissed cruisers of high speed, and a new type devised by the author, and called by him the gunboat. This young writer, who has since died, was supposed to express the ideas of Admiral Aube, who is now Minister of the Marine. In fact, one of the first acts of Admiral Aube, on coming into power, was to apply the theories set forth by Mr. Charmes, by ordering the construction of a gunboat, which has just been tried at Toulon, and which we herewith illustrate.

Externally, this gunboat has nearly the lines and dimensions of a torpedo boat. She is 134½ ft. in length, 12½ ft. in width amidships, and 8½ ft. in depth. Her hull weighs 27 tons, her artillery 11½ tons, and her machinery 22 tons. Her engine, which is of the compound type, is of 560 horse power, and is to give her a speed of 19 knots, or 15 miles, per hour.

Upon so light a vessel, it was not easy to place a piece of artillery without overloading, nor especially to fire the piece without running the risk of dislodging the plates and timbers of the hull. The problem was solved in the most remarkable way by Mr. Lagane, engineer in chief of the Forges and Shops of the Mediterranean, who superintended the construction of the boat, and especially by Mr. Canet, the eminent engineer, who directs the artillery service in this great maritime establishment.

Mr. Canet devised a gun carriage which, after a manner, stores up the force of the recoil at the moment of firing, and which afterward gives it up like a spring, so that the piece puts itself automatically in battery after each discharge. The apparatus that thus perform the *role* of springs, and absorb the recoil so perfectly that it is limited to two inches, and also greatly reduce the shock on the deck, are hydraulic brakes of Mr. Canet's inventing.

The gun (model of 1881) has a caliber of 5½ inches. Notwithstanding its small dimensions, very destructive effects are obtained with the very energetic explosives that are now employed.

As may be seen from our general view, the piece is placed in front of the pilot house, as in torpedo boats. It is from this house that the horizontal aiming is done, by displacing the boat by means of the rudder wheel. The upward aiming is effected upon the carriage, and varies from the horizontal up to thirty degrees. The projectile weighs 66 lb. and the charge is 30 lb. The firing may be done at the rate of one discharge per minute.

The piece is surrounded with iron plate, which protects it against the sea. The ammunition is placed beneath the deck, in the interior part of the ship, as shown in our second engraving. The cartridge and projectile magazines are situated to the right and left of a central passageway, from whence they are hoisted by means of a pulley up to a platform above.

This first gunboat has been christened the Gabriel Charmes. On trial, she has given the most satisfactory results, from a nautical point of view, the bow rising well up in view despite the weight with which it is loaded, and the speed reaching 20 knots—that is to say, exceeding previous calculations.—*L'Illustration.*

STREET PAVEMENTS.*

In answer to the query referred to the Committee on Streets at the meeting June 1, 1886, "What is the best pavement, or improved roadway, for a city residence street having a limited amount of travel?" the following discussion was had:

C. P. Matlack, San Antonio, Texas: During the last year I have put down about four miles of gravel roadway on a Telford foundation. These are the specifications for the roadway:

"The earth roadbed on which the pavement is to rest is to be excavated to subgrade twelve (12) inches below and parallel with the legal grade and finished surface of the street; and, when graded and shaped to its proper form and cross section, it is to be thoroughly and repeatedly rolled with the steam roller, and all depressions which then appear are to be filled in with the same material as the roadbed, and rolled until the whole becomes uniformly compact and solid.

"Upon the roadbed thus formed and compacted shall be deposited a layer of spalls and broken stone—the dimensions of the stone to be as nearly uniform as possible. The stone shall be free from dust and dirt. After being placed in position, this layer shall be thoroughly rolled to a true and even surface; any depressions to be filled up and rerolled. The layer to be six inches thick after consolidation, and the surface to be parallel to the established cross section and finished surface of the street.

"Gutters are to be paved with mesquite blocks fifteen inches long, three inches thick, and five inches deep, resting upon the stone foundation above specified, with an intermediate layer of fine screened gravel; the blocks laid close and at right angles to the axis of the street.

"The gravel forming the intermediate and surface layers must pass through screens of the following sizes: 1st size, screens with meshes one-half inch square; 2d size, screens with meshes two inches square.

"The intermediate layer of gravel to consist of second size screenings, as described above. The layer must be three (3) inches thick after being thoroughly consolidated by the roller. The rolling to begin at the gutter and be gradually worked toward the center. On its upper surface it must be identical in rise and form to the cross section of the finished surface.

"In laying this course, a small quantity of binding material is to be used, sufficient only to fill up crevices and render this portion of the pavement solid.

"The binding material may be of fine screened gravel or sand, which is to be sufficiently watered during the process of rolling to prevent adherence to the roller.

"On the intermediate course is to be laid the surface layer of gravel. It must be three (3) inches in depth, after being consolidated by rolling.

"This layer is to consist of screenings of the first size, as described above, and to contain no large stones whatever.

"The material is to be raked to an even surface and the roller passed over it two or three times.

"The surface is then to be sprinkled and the rolling continued, working the roller backward and forward gradually from the gutter toward the center, with an occasional light watering of the pavement and the addition of the necessary material until the cross section is exact according to specification, and the roadway firmly compacted and solid."

The material we have here at hand is a very soft limestone, which can be easily worked, and a closely paved foundation can be obtained at moderate expense. The gravel is very hard flint, of irregular shape, and not water-worn. The screenings from the gravel which we use for binder consist of small particles of flint and grit, mixed with clay and black soil. The specifications have been very well carried out, with the exception that I have found it better to make the layers of gravel four inches and two inches, and have the top two inches of gravel put through a ¾ inch mesh instead of a ½ inch.

Before rolling the middle layer of gravel I have had it well sprinkled, and not rolled until the top had dried enough not to stick to the roller, the rolling being continued on this layer until the stones were well settled in place and did not mount up before the roller. Bare places will appear on the surface, caused by the fine binding material sifting down through the stone. No attempt has been made to cover them up. The top two inches has received most of the rolling. After it has been brought to a firm surface, it has been thoroughly wet, in fact flushed, and rolled repeatedly in that condition. The surplus clay and dirt will work to the surface, where it is kept so thin that it will not stick. The result is that all the fine gravel is firmly bedded, and the surface is hard and smooth. As an experiment, I had sand spread over the surface of a small piece while the top was being rolled. I found it to be a great improvement, but it was not kept up on account of the expense. The first piece of work was finished about seven months ago, and since that time it has been subjected to a continual travel, consisting of country wagons, wood wagons, and a great deal of light driving.

Although no attention has been paid to it in the way of repairs, there is no showing of ruts or uneven wear as yet.

In a short time I expect to put down a short piece of street with gravel only, leaving out the Telford foundation, when I can compare the results as to duration. I believe, however, for light travel, with a firm soil, that a cheap and durable roadway can be obtained at a small cost, provided the subgrade is thoroughly rolled, and provision made for underdrainage.

The contract price for the Telford work is 76½c. per sq. yd. of finished surface; excavation, 29½c. per cu. yard; curbing, 54⅛c. per lineal foot; gutter, 27½c. per lineal foot.

This price, however, is low, and the contractor has lost money. I consider $1 per square yard a fair price for the best workmanship and carefully selected material.

The greater parts of the roads have been built on a black, sticky soil, which when wet gets very soft, and is almost entirely impervious to water. When dry it is very hard, and cracks open. The work is hardly old enough yet to make any very valuable comparisons.

Mr. C. B. Holmes: The Chicago City Railway Company has used wood extensively in paving its tracks, and has a large variety of it—pine, hemlock, cedar, maple, elm, gumwood, and lignum-vitæ. The gumwood was in round blocks, and in a short time wore into an oval shape like a saucer inverted, and became so objectionable for horses to travel on we had to take it out. None of the woods lasted for a satisfactory period, and all were very hard on horses. When frozen, the animals would strain all the cords and muscles to retain a foothold on the slippery pavement, and soon became disabled, many of them falling and breaking limbs or otherwise injuring them. In the summer time the case was but little better when the blocks were wet and "greasy." On State street, from Madison to Lake street, the company renewed the pavement regularly every six months, and sometimes it would last only four months; but in my estimation a much more serious objection to wood is the effect on health. Let any person come into the city from the lake or the country, where air is pure, any warm morning in summer, just after a shower, and walk down any street which has been paved for six months with wood, and he can taste the bitter poison in the air which comes from the fermentation and decomposition of the fibers of the wood, saturated with the vilest of excrements and droppings from the horses, and the wind blows these germs of disease into the houses of the people, causing diphtheria and scarlet fever and kindred diseases, which prevail to such an alarming extent in a city paved with wood. Our experience, extending over a long term of years, condemns utterly all kinds of wood pavement, for the reasons given: Short lived, always out of repair, expensive, and very unhealthy. My motto is, *anything but wood.*

The President: Mr. Holmes, what would you recommend for a street pavement?

Mr. Holmes: A good substantial granite block on a business street where heavy trucking is done and in all horse paths of street railways, and in residence streets a macadam foundation, with a good substantial dressing of from three to six inches of crushed granite rolled with a heavy roller, the heavier the better. This secures a clean, permanent, healthy, quiet pavement.

Mr. L. P. Morehouse: By the "best roadway for residence streets" I understand that which is the best or most satisfactory so far as the residents or property owners are concerned. It is, however, possible that a non-resident owner might be satisfied with a pavement which might be very objectionable to a resident non-owner, and the latter might require a much more expensive pavement than the owner would be willing to pay for. So that I think the question really resolves itself into asking what is the most satisfactory pavement for the resident owner, the man who has to pay for the improvement and its renewal, and to live with his family in daily contact with what may be a great source of comfort or of annoyance. I have often driven over very excellent roads alongside of which I should have been most unwilling to live. To insure a comfortable paved street for its residents, there must be freedom from noise, dust, and mud; and to satisfy the property owner, these advantages must be obtained at a reasonable expense. Practically, therefore, it is impossible to answer the question as it stands, for the "best" pavement, costing, say, three dollars a square yard, might be very unsatisfactory to an owner who was only willing to pay fifty cents a yard. Absolute freedom from noise, dust, and mud can only be obtained by the expenditure of considerable money; more, in fact, than most owners are willing to spend for this purpose, the majority of people expecting to put up with more or less of discomfort in this matter, as in most others. The asphaltum pavements, either continuous as sheet asphaltum or in blocks, claim the highest excellence in cleanliness and durability, but their high cost—$2.50 to $3.50 per yard—I think forbids their use except upon the best residence streets. I say "forbids their use" as a matter of fact, not, perhaps, of necessity, for their advocates will tell us that the comparatively high first cost is compensated for by their advantages over less durable and desirable pavements. The only objections that I have heard urged against these pavements are the unpleasant clickling of horses' hoofs on them, and their smoothness, which, when they are unsprinkled, allows the dirt tracked on to them to blow off in fine dust. So far as I am aware, the wooden block pavement comes next in its claim for comfort, and has the pecuniary advantage over asphalt in its first cost, which ranges from a dollar to a dollar and a half a yard. Mr. Holmes takes the position that the wood pavement is unhealthy, and states that the odors arising from it after a rain are very unpleasant. Some of our members have been much in favor of this pavement, and I should like to hear from them on these points. Mr. Greeley has laid a great deal of wood pavement in the city, and I presume Mr. Bullard can say what the results thus far are in Springfield, Ill., where the cedar block has been used extensively during the last five or six years. I lived for several years on a street paved with the Nicholson, and found it very satisfactory so far as noise and dust were concerned, so long as the pavement remained in good condition. The street was sprinkled only to a very limited extent, but there was very little annoyance from dust. Waiving the matter of healthfulness, it is a mooted question, however, whether the first cost is enough lower than that of asphaltum to offset the expense and discomfort occasioned by the perishable nature of the material. Let us hear something on this point. How long will the wooden pavement remain in good condition? Ten years—twelve years—fifteen years? Many of us have seen wooden pavements go to pieces in three or four years. But if the wooden block pavement is not unhealthy, and will retain an even surface for ten years, with light repairs, it certainly has strong claims for adoption on resident streets. The average owner would probably prefer to renew this once in ten years at a cost half that of asphaltum rather than pay a hundred per cent. more at first for a pavement that would last two or three times as long. If both be unsprinkled, it seems to me that a new block pavement is as free from dust, mud, and noise as the more expensive asphaltum. Now, for how long a time can we maintain this condition for the wood? Can we materially lengthen it by a system of judicious repairs?

With regard to macadam and gravel roads, their character is generally determined by the material most available for the purpose. Mr. Matlack, for his San Antonio streets, appears to be quite fortunate, the stone and gravel working so well together. In many localities the material used is very objectionable on account of the dust, the top dressing and upper layers grinding up, under the traffic, into a fine powder that becomes a most serious annoyance whenever a brisk breeze stirs it up and carries it into the houses of the much suffering residents. It must be admitted, from our standpoint, that such roads are not satisfactory.

Particular care should be taken to secure material that will give the minimum of dust. Under the delusion that a road which is satisfactory for driving purposes is necessarily a desirable improvement for the persons residing on it, we find that the average householder accepts such a road as a matter of course, and submits to the rapid deterioration of his furniture and his wife's good nature with a feeling of what he may suppose to be content, but which is really resignation. He will tell you that there is no trouble from dust, as the road is kept well sprinkled, but as this practice is kept up only about half the year, it is plain that, for a considerable portion of the time, there can be no relief. Indeed, the times of the year when the winds are the highest are those when it is impossible to get any sprinkling done.

Admitting that a wooden block pavement will accumulate some dirt and produce some dust, and, on the other hand, that we are willing to pay six months in the year for sprinkling a macadam road, I think that the average of dust on the unsprinkled wood paved street would be less than that on the sprinkled macadam. Now we are considering a residence street with a limited amount of travel, which indicates that the street is not built up in continuous blocks. There are unoccupied lots owned by non-residents, and to insure freedom from dust the residents must pay for sprinkling in front of these as well as in front of their own property.

The resident owner of fifty feet frontage must then expect to pay at least fifteen dollars annually for this purpose. If the block pavement is more desirable, the owner would be warranted in borrowing $100, payable at the end of ten years, at 5 per cent. annual interest, for the yearly amount of fifteen dollars would put aside one-tenth of the principal and pay the interest. If the roadway were thirty-six feet wide, the fifty feet would have to pay for 100 square yards, so that on this basis the owner could afford to pay a dollar a yard more for the block than for the macadam. But if the element of dust can be eliminated from the macadam or gravel road, we ought to obtain the most satisfactory road, for the first cost and the maintenance should be less, and the durability much greater than that of the wood pavement. My personal experience with the former is that they are very objectionable on account of the dust.

I should like to hear from others on this point. Mr. Powell has put a top dressing of crushed granite on some streets in Hyde Park, and, perhaps, he can tell us if this obviates the evil. The ordinary macadamized

* A discussion by members of the Western Society of Engineers.

streets in Hyde Park are very dusty, except when well wet down.

Mr. Matlack thinks that his road should cost about a dollar a yard, and this, I believe, is about the cost of macadam roads put down in and about Chicago. For many localities, however, it is necessary to have a cheaper road than this. There are places where non-resident owners are unwilling and cannot be obliged to incur any expense, and the residents are, under the circumstances, willing to do all the work if it can be done very cheaply, or the tracts may have a large frontage, requiring a large expense for each owner, even at the minimum cost per yard or lineal foot. What will you give us for these?

The ordinary macadam road has a foundation of large stones, the successive layers growing smaller and smaller, but I have noticed excellent roads, or rather short sections, which had been made simply by the deposit of house ashes, year after year, in the sand of the highway in front of the houses. Having occasion to excavate through one of these sections, I found the material almost as hard as rock. Will some one tell us if the solidification is due to the union of the sand with the ashes, or will the ashes of themselves, under pressure, bind sufficiently to make a compact mass suitable for a roadway? In other words, can you by means of a heavy roller make a good road of house ashes alone?

Rolling mill cinders are used locally to some extent for roads, but I should think that, perhaps, house ashes mixed with them might be an improvement. Can any one speak as to this?

The subject opened up by the query is a pretty broad one, but, perhaps, the discussion of cheap suburban roads is the most important part of it.

Mr. S. A. Bullard: A pavement for a street must be (*a*) serviceable, (*b*) economical, (*c*) inoffensive, in order to be satisfactory to those who use or pay for it. Opinions are generally based on an examination from one or other of these standpoints and necessarily result in a wide difference of opinions. The truckman judges of a pavement from the service he gets out of it, the ease or difficulty with which he hauls his loads. The taxpayer from the points of cost and durability. The resident from the convenience or inconvenience he enjoys or endures. The physician from the effects it has upon the health of his patients and patrons. And public opinion we know to be a jargon with a sound for every one of the multitudinous business affairs of man. Probably no one pavement will fill the requirements of being serviceable, economical, and inoffensive, though some approximate nearer than others to them.

Serviceable.—A pavement for the street under discussion should be of a firm, smooth, regular surface, not entirely unyielding, such as asphalt, wood block, or burned clay.

Economical.—The pavement should be of such first cost as not to be an overburden to the property owner. The pavement that is to be often renewed may not be necessarily an extravagant one. A pavement costing $1.50 per yard, and requiring renewal every ten years, is more economical than one costing three dollars per yard with renewal every thirty years. That is, the interest on the difference of cost of the two pavements will pay the renewal of the cheaper one. There would be a period in the life of either pavement of inconvenience, just before renewal, when the pavement would be poor, but a further comparison is extremely unfavorable to the longer lived pavement, inasmuch as the cost of its renewal is an entirely new outlay. I should think that for the street under discussion the cheaper pavement would be the most desirable, unless it lay in a wealthy city or suburb where the property owners were in circumstances enabling them to consult their taste rather than their purse in the contemplated improvement. However, I have never yet seen a whole street owned by that class of people, though individuals of that class are not infrequently met.

The economical pavement is one having moderately lasting qualities, and having a correspondingly moderate cost.

Inoffensiveness.—Pavements give offense (*a*) by the presence of disease-producing germs, (*b*) making or wearing into dust, (*c*) giving rise to noise in the passage of vehicles. The first source of offense is most serious, and should never be overlooked. When a pavement produces or distributes disease germs, it should be at once removed as a public nuisance. The second source—the wear of a pavement—the wear should never be so rapid as to make the accumulation of dust or dirt on the street from that cause perceptible. The tracking of dirt or mud on pavements will probably be as great on one as on another. The third source is determined by the smoothness of the surface and the yielding qualities of the materials. Now, what pavement or pavements under the light of these statements would be most acceptable to impartial and disinterested parties acting as judges?

Let us place them before us in a tabulated form:

(A.) Granite block pavement. Service—Reasonably good. Economy—High cost, but long lived. Inoffensiveness—Noisy, some dust, healthful.

(B.) Macadam, with limestone surface. Service—Acceptable. Economy—Moderate cost, but needing constant repairs. Inoffensiveness—Little noise, dust intolerable, healthful.

(C.) Macadam, with crushed granite surface. Service—Acceptable. Economy—Expensive. Inoffensiveness—Little noise, dust tolerable, healthful.

(D.) Asphaltum. Service—Very good. Economy—High cost, but not long lived in this climate. Inoffensiveness—Little noise, no dust, healthful.

(E.) Wood block. Service—Very good. Economy—Moderate cost, medium life. Inoffensiveness—Little noise, no dust, healthful, except the last year or two.

(F.) Burned clay blocks. Service—Very good, Economy—Moderate cost, long life. Inoffensiveness—Little noise, little dust, healthful.

As the granite block, macadam, and asphaltum pavements would be expensive on account of first cost, the only pavements I think we should consider as suitable for the street under discussion would be wood block, or tile, or burned clay. If stone is so near the street to be paved that freight will be trifling, then macadam pavement would not much exceed in cost that of wood block or burned clay. Gravel streets I have not considered, because of the impossibility to keep them clean at cross unpaved streets in our soil. In removing the accumulated earth the surface of the pavement is disturbed, and rapid disintegration takes place, requiring expensive repairs.

The wood block pavement will not wear out on the street under discussion before it will have to be replaced on account of decay. The white cedar block, of which we have laid a great deal in Springfield, has a life on an average of ten years without expensive repairs before renewal.

The first cost of pavement is about $1.35 per yard, everything included. It can be replaced at $1.20 per yard, the excavation not having to be done. The effect of the cedar block pavement on the health of the community is not at all injurious until decay has reduced the blocks in places to a mass. Then it is bad, and should be condemned and ordered removed. The pavement, for two years before renewal, could not be called a good pavement for traffic or light travel, and is certainly not conducive to the good health of the residents thereon. It is not a pavement, therefore, without objections, and cannot be fully recommended for the street under consideration.

The burned clay pavement has many qualities very commendable. The noise is comparatively nothing, the pieces are so evenly joined that friction or attrition is trifling. The pavement presents an even surface and stands travel and wear well. The cost is not much in excess of the white cedar block, being about $1.60 per yard complete. There is no decay. The healthfulness of it is unquestioned, being such as granite or macadam pavements, and the durability will certainly reach twenty or more years if the pavement be made a piece of the shape of common brick, but if made in forms more suitable for paving, would last much longer.

I should think that for a residence street, having little heavy travel, a burned clay pavement is much to be preferred to any other, considering the service required, economy, and the inoffensiveness of the pavement.

Another advantage burned clay has as a paving material is that it can be produced in almost every locality, while stone, cedar blocks, and asphaltum have to be shipped long distances. The advantage would be local only, and though the city or community in which the street is would be helped by the additional business of making and producing the paving materials, that would, perhaps, be of no financial consequence to the property owners who pay for the pavement.

When cities have experimented sufficiently with burned clay pavements, and proved they may be produced and laid in any locality, using local labor and capital entirely in their production, then will they come into much more popular favor, and the paving interests of smaller cities will be greatly advanced thereby.

Mr. L. P. Morehouse: Brick pavements are coming into considerable use in the towns of central Illinois. The city of Bloomington, I think, was the pioneer. I am informed that streets laid there ten years ago are still in first-rate condition. In the city of Decatur I noticed, a few days ago, that some of the principal streets are being paved with bricks. Mr. Burgess, city engineer, is laying these pavements, under the following specifications:

"Said street, for the distance of........feet on each side of the central line thereof, shall be excavated to the depth of 12 inches along the central line thereof, below the established grade thereof, and at the outer edges of said street, where the same is so excavated, on either side thereof at a distance of........inches toward the center of said street, respectively, to the depth of........inches, the said excavation of said street to be in the form of a segment of a circle. The portion of said street between said........inch lines, aforesaid, and the outer edges of said street so excavated, on both sides thereof, shall be so graded and paved in a similar manner as the balance of said street, so as to make a good and substantial gutter along said........inch lines; and when said street shall have been so excavated, there shall be placed thereon a bed of sand and gravel 4 inches in depth, said sand and gravel to be well tamped, so as to form a smooth and compact surface; and on said bed of sand and gravel, so tamped and made smooth, shall be laid on their flat surface a close floor of hard burned, sound, and shapely paving brick, said brick to be laid longitudinally with the street, and the joints broken in each course; said brick to be put closely together, so as to form a smooth and solid floor, no broken or cracked brick to be used; over said floor of brick so laid there shall be placed a layer of screened sand... ....inch in thickness, so as to fill all crevices, and made smooth, so as to form an even floor for the subsequent layer of brick; upon said layer of sand so made smooth there shall be placed and laid on their edges, in close contact with each other, a layer of extra hard burned paving brick, said brick to be laid at right angles with the line of said street, joints to be broken in each alternate course, all brick being sound and of full size; after said bricks are so laid a thin layer of screened, dry sand shall be swept over said pavement, so as to fill all crevices therein, after which a top dressing of clean unscreened gravel, not less than one inch in depth, shall be placed over the entire surface of said improvement. There shall be two cross-walks at the intersection of each street, one on each side, so as to connect with the sidewalks, of the width of 6 feet, to be formed by an oval elevation across said street, so that the center of each cross-walk will be 4 inches below the grade of the sidewalk with which they connect, and slope to meet the grade of the street, and to extend to a point within 4 feet of the outer edges of said improvement, so that aprons may be placed over the gutters."

I am in hopes that Mr. Bell, of Bloomington, will let us hear from him on this question.

Professor I. O. Baker: In Champaign we have used the brick pavement for about three years, and they give excellent satisfaction.

Mr. A. H. Bell: The question as to the most suitable material for street paving in various localities is one which is the concern of municipalities in all sections of the country. So far as the city of Bloomington, Ill., is concerned, this question is at rest. We have tried stone blocks, Nicholson and macadam pavements, and still have samples of each from which to draw our conclusions; but the citizens of Bloomington are a unit in favor of brick for future street pavements. The reasons for this are cost, durability, lack of noise, and general satisfaction, to which might be added the fact that we produce the brick at home, thus patronizing home industry and avoiding freights. The first piece of brick pavement was laid here about nine years ago, on the west side of the Court House Square. It was laid under the general specifications which will be given later on, and is still down and in very good condition, having had but very slight repairs, where excavations were made for sewerage or other purposes. Last year there were laid about 9,000 yards of brick pavement; this year we have laid probably 12,000 yards. It presents a very desirable surface, and gives universal satisfaction. No complaints are brought against the use of brick for pavements, so far as our experience goes. The pavement is easily kept clean, easily repaired, or removed for excavation purposes; it is noiseless and pleasant to drive over if properly laid. What was laid during the present year in Bloomington cost $1.15 per square yard for the brick and the laying of the same in pavement. The city did all grading, and furnished all necessary sand and cinders. The entire pavement, including *all material*, grading of lawns, etc., also stone curbing (4 inches by 30 inches), cost $2 per square yard. The best paving brick in this locality are quoted at $10 per M. Laborers cost $1.60 per day, teams $3.25, and sand costs, 80@90 cents per cubic yard delivered on the work. In the business portion of the city we are paving the entire street between sidewalks; in the residence portion we pave from 30 to 36 feet in width, leaving the balance of the street for sidewalks and lawns. The cross section of the pavement is in the shape of an arc, with a rise of 6 inches in the center (for 36 feet wide), and the stone curbing 1 inch above the center of the pavement, thus exposing 7 inches of stone to view. The drainage is provided for by means of inlets through the stone curbing into sewer pipes leading into the main sewer, similar to the system used at Springfield, Ill. The general construction of our brick pavements is as follows: The foundation, being brought as nearly to the proper grade and shape as possible, is thoroughly rolled with a roller weighing at least two tons (the stone curbing, of course, being previously set). There is then spread over the whole a course of about 2 inches of cinders (gravel would do as well, I presume), which is *thoroughly rolled and compacted*, care being taken at all times to retain the uniform shape and grade. This course of cinders should be rolled until it is *very compact* and hard, and great care should be exercised to have it in the exact shape and form desired for the surface of the pavement. Upon this cinder bed so prepared is placed a course of 2 inches of sand. This is carefully gauged by means of boards having the proper convexity, and is the final course for receiving the brick. A course of bricks is now laid on their flat surface, the longest dimensions being in the direction of the street, and care being taken to break the joints. It is not necessary that the bricks in this course should be as hard and tough as those in the upper layer, as they do not receive the traffic, but only fulfill the purpose of a foundation for the *upper course* of bricks, which must be of the hardest and toughest that can be procured. Having so placed a course of bricks upon their flat surface, and covered the same with an inch of screened sand, the upper or final layer is laid across the street upon their longest 2 inch surface; care being taken to break joints as before, and to place the convex edge of the brick up, where any convexity exists. The whole is then covered with sand (screened), which is continuously swept into the crevices and rolled with a heavy roller (not less than two tons being of much service).

This final rolling is of much importance, and will render the surface of the pavement as good as any Nicholson or wooden block pavement I have ever seen laid, if the other precautions mentioned are observed, and the bricks have any degree of uniformity. I am a strong advocate of brick pavements in those sections of the country where a suitable article of brick can be obtained. The durability of the pavement will depend much upon the quality of the material. The bricks should be very hard burnt, almost vitrified, particularly the upper course. Toughness and tenacity are the desirable qualifications to secure durability. I am not prepared to state how these pavements would stand in the streets of large cities, where they would be subjected to very heavy traffic, but even there I believe they would surprise the profession if constructed with proper care.

There is so much dependent upon the manner in which a brick pavement is constructed, that the article has scarcely had a fair trial in this country as yet. We have one street paved in Bloomington, running from the Union Depot to the Court House, over which there is a great deal of heavy traffic, nearly all the coal used in the city being carried over this pavement, besides a great deal of heavy hauling of a general character. This street was paved early last year, and shows no appreciable signs of wear as yet. Of course its life has been short, but if the brick were going to yield to heavy traffic, sufficient time has elapsed to give some indications, which are not visible. The heaviest grade we have yet laid brick on is that of 4 feet to the 100 feet. We have experienced no trouble from slipping, and I believe they could be satisfactorily laid on much heavier grades.

Mr. Wright: I have had no experience with brick pavements, and should favor round cedar blocks for such a street, having a light traffic. Such a pavement has been laid in Chicago for 97c. per square yard. It is cheap in first cost and durable under the above conditions. When the traffic is heavy, it will last only a short time. It does not wear as well as pine blocks of average quality, and in the down town tracks of the North Chicago City Railway new pine block pavement was worn within six months, requiring repairs, and within eleven months an inch and a half had worn off, and the entire pavement had to be replaced.

The durability of wooden pavements depends upon the amount of traffic, upon the soundness of the wood used, upon the kind of wood, upon the season of year at which it is felled, upon the seasoning of the timber, upon the foundation, upon the care and thoroughness with which it is laid, and upon the condition in which the surface of the pavement is maintained.

The sprinkling of the street has much to do with the durability of the wood pavement. I have seen adjacent pieces of pavement where part was thoroughly sprinkled several times daily, remain sound and free from decay at least three times as long as that unsprinkled. Cedar block pavement between the tracks of the North Chicago City Railway (*not* in horse paths)

was comparatively sound at the expiration of ten years.

The cedar block pavement, possessing the advantages of noiselessness, cheapness, and durability, would be my preference for a suburban street with light traffic, but the blocks should all be sound, well and thoroughly laid and rammed, and the pavement sprinkled and cleaned.—*Journal A. E. S.*

TWO MODERN CHIMNEYS—A STUDY OF THEIR DESIGN AND CONSTRUCTION.

By C. POWELL KARR, C.E., Consulting Architect, New York.

I.

THE primary object of a chimney is to create a draught, to obtain a current of air by means of a difference in density of the air contained within from that without the shaft. The force exerted is really caused by the continuous formation of a partial vacuum in the shaft and a constant effort on the part of the surrounding air to fill that vacuum. This movement of the air is a ponderable force, and can be measured in various ways, either by the velocity of the current, by the dials of pressure gauges, or by the quantity of air evacuated in a given time.

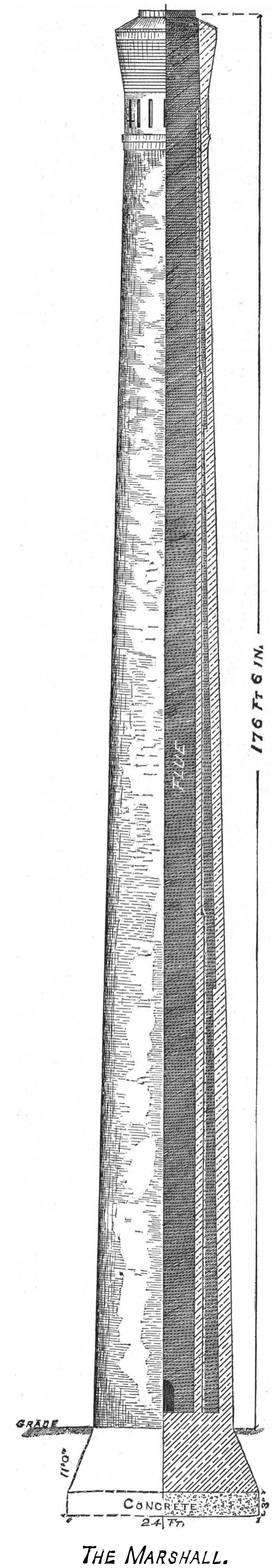
Chimneys are made square, hexagonal, octagonal, or circular in section, the latter form being considered the most economical in chimneys of large section, and from an enginneer's point of view are the most secure as to stability. Chimneys are noted for their plainness, not to say ugliness, of shape and poverty of ornament, and the question is often asked, Have chimneys any claim to architectural treatment? The writer will try to answer that query in this article.

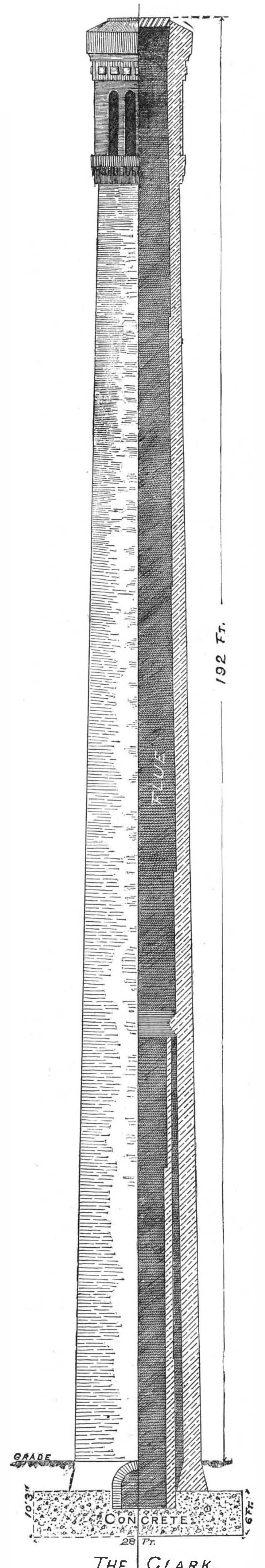
The two chimneys before us are taken as types of their class; they represent the care, thought, and years of experience of two of the best known mechanical engineers of the country. The square and round section have been chosen in order that both types may be studied by contrast. Comparisons are said to be odious, but the odium does not extend to the principles upon which the comparisons are based. The two stacks are situated in the town of Kearney, a suburb of Newark, New Jersey. They are placed about five hundred feet back from the Passaic River, are within hail almost of each other, and are the respective steam factory chimneys of two of the largest thread works in the United States. The Clark stack was built in 1882 for the Clark Thread Company of Newark, New Jersey. It was built by days' labor. The care attending its construction necessitated a much longer time to complete it than would have been permitted had it been let to a contractor. In drawing, Fig. 6, we show a sectional elevation of the foundation as originally designed before the soundings has been completed, and also in drawing No. 6 the foundation as it now exists, and decided upon after the soundings were completed. This evolution of the foundation is worthy of study. The surface soil was removed and a good bed of river gravel struck; beneath the gravel, however, the sounding rod revealed a bed of quicksand, beneath the quicksand a bed of clay. The rod was driven down some thirty feet. Upon striking what is called water level, the engineer determined to widen the concrete base from twenty-four feet to twenty-eight feet square. It was necessary to distribute the load over a greater area. No separate accounts having been kept of the construction of the chimney from that of the mill to which it belongs, the writer has been obliged to calculate approximately some of the elements of the chimney. It stands entirely alone, and free from masonry connection with any of the adjoining buildings. The connecting flues from the boiler houses are built underground, and have an underground entrance into the chimney, as shown in the general drawing. All of the flues are of the differential order, and where two flues are so situated as to combine and form one flue, the combination is made and a division plate of iron placed in the center, just far enough to give direction to the outgoing current of heated air. The final differential is calculated so that its greatest sectional area is a trifle larger than the sum of the areas of all the flues which discharge into it. The underground flues may be protected from convection and radiation either by air jackets or linings of a mineral nature.

The stack is one hundred and ninety-two feet high, and is estimated to contain about 600,000 bricks. One thousand brick, with one-quarter inch joints, laid in Portland cement mortar will weigh about 5,412 lb. Upon this basis the brick alone will weigh 1,624 tons. The concrete bed will be obliged to sustain two tons per square foot of area. If the foundation had been put in as originally planned, the load would amount to 2·8 tons per square foot of area.

The cost of the structure is based on the use of good, selected North River brick both inside and out, laid in good cement mortar. Such brick masonry can be laid at twenty dollars per thousand, and the concrete at six dollars per cubic yard. The chimney will contain 600,000 brick and 297·6 cubic yards of concrete. At these figures the chimney could be built for about fourteen thousand dollars. The brick externally and internally are laid in Portland and Rosendale cement, with the exception of the chapter and the courses below grade; the excepted portions are laid wholly in the best Portland cement. As the designer of the stack believes that the temperature in steam chimney flues never exceeds 400° Fahr., and is generally much lower, he has come to the conclusion that it is unnecessary to line any steam chimney with fire brick, and that good hard burned North River or other equally good brick are sufficiently refractory to withstand all the heat they will be exposed to in a steam chimney.

The Clark chimney was designed for a working horse power capacity of 2,400, although but 1,800 horse power is used, on account of the last nest of boilers not yet having been placed in position. There are twelve boilers of 150 horse power each in use, and each boiler has a grate area of 42 square ft. In general it has been thought better practice to calculate from the cubic capacity of the chimney flue its evacuation power than to depend upon the height and the area of the discharging mouth. The practice of European engineers is to depend upon the two last elements. In this stack the difference between the area at grade and that at the mouth is so slight as not to be essential. The area of the chimney mouth is made equal, nearly, to one-tenth of the total grade area. About thirty-five feet above grade the reader will observe a contracted cross sectional area, called a *vena contracta*, and its application is based upon the well-known principles of hydraulics in regard to the discharge of any fluid through an orifice. Great improvement in the draught has been effected by the *vena contracta* throat. Another object has been served in this case by making the brick, as they rack inward, cover the open space between the internal

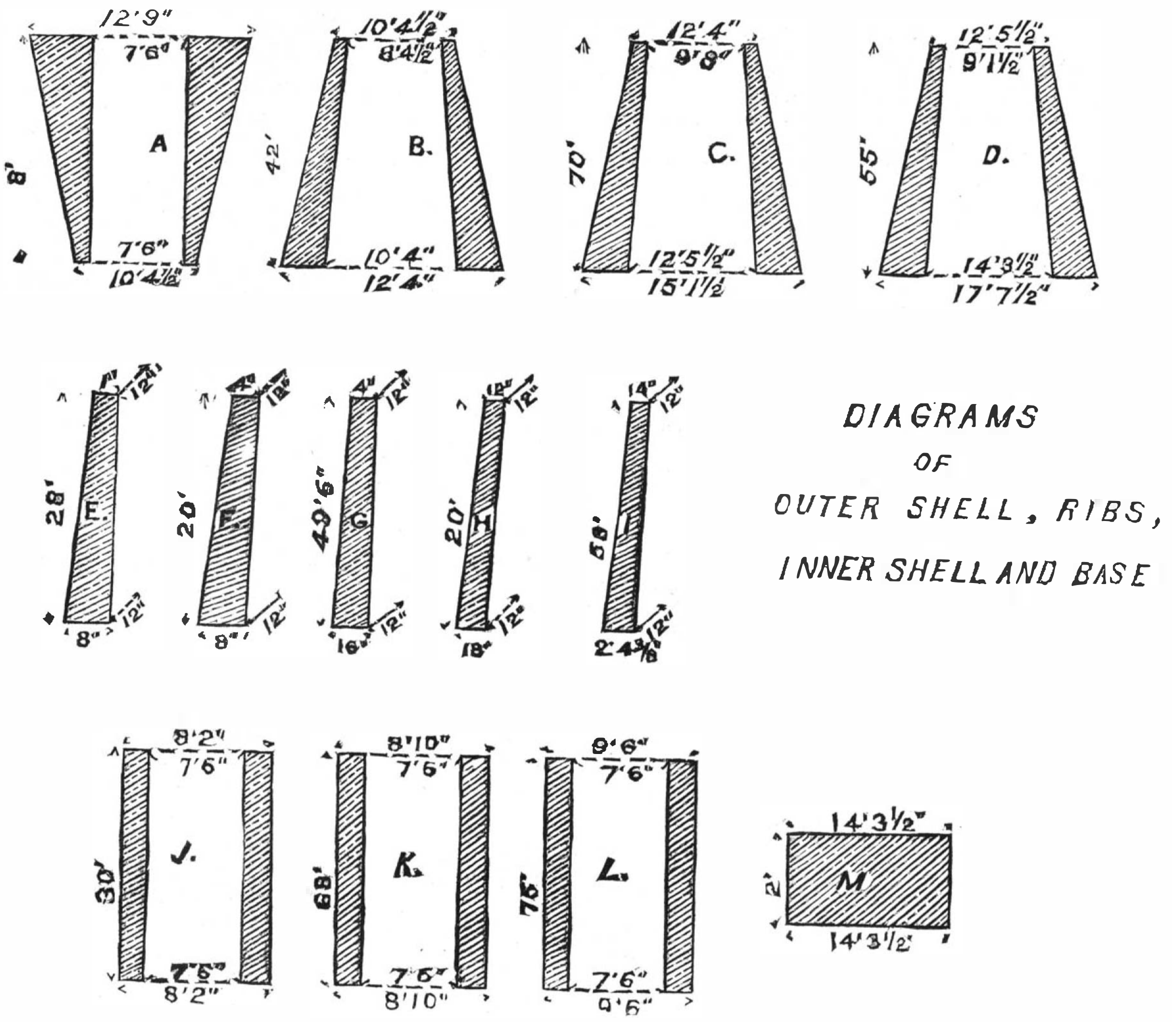




TWO MODERN CHIMNEYS.

flue and the exterior wall. The design of this is to prevent the accumulation of soot and dirt between the outer and inner shell. This deposit of soot or dirt filling in the air space promotes the convection and radiation of heat from within outward and the transmission of sudden changes of temperature in the external air, and involves a loss of power in the chimney.

In the various contractions of the chimney flue, care has been taken that the area of the outlet shall be maintained as a minimum. The thickness of the outer shell at any given point has been made commensurable with some known brick dimension as a unit; thus the thickness at the bottom may be said to be four bricks, the second thickness three and one-half bricks, the unit being four inches. The width of the chimney at grade is 17 ft., and at the top of the shaft proper, just below the chapter, 10 ft. 9 in. The batter of the exterior faces is about twenty-two one-hundredths of an inch to the foot, making the total batter 6 ft. 3 in. From the grade line to the beginning of the chapter the distance is 170 ft.



DIAGRAMS OF OUTER SHELL, RIBS, INNER SHELL AND BASE

The arcade openings in the chapter are 1 ft. 4 in. wide, 4 in. deep, and 8 ft. 8 in. from the belt course to the intrados of the arches, and from the belt course to the spring lines 8 ft., thus making the radii 8 in. The chimney is capped with a 1 in. cast iron hood, anchored to the masonry by an inch and a half iron bolt some four feet long. The top face of the iron cap has a slope of one to two. This is designed to direct any current of wind upward that strikes the top of the plate normal to its surface. The consequence of this would be to produce an induced upward current in the chimney, and a current of air striking this plate at any angle would be deflected either upward or downward, and thus produce a good result or not impede the draught. The objection to an arcaded chapter is the tendency to promote eddies and swirls of wind, and thus conflict with the calculated effect of the chimney.

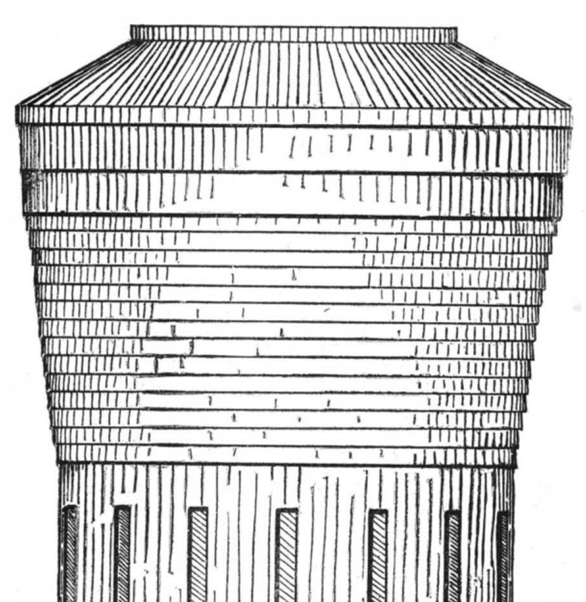


FIG 1 CHAPTER.

By an examination of the drawings, it will be observed that the outer shell and the inner shell are built independent of each other after leaving the foundations. Vertical ribs are built inward from the outer shell, approaching to within three-eighths of an inch of the inner shell. Should there be a slight deviation of the outer shell from the perpendicular, owing to a concentrated pressure of the wind or unequal settlement, the outer shell will receive some support from the inner shell. The inner shell may be depended upon to give warning of a collapse of the chimney. The intention in construction is to build the two shells separate, in order to keep the inner shell from being chilled by a sudden lowering of the external temperature. Air being such a good non-conductor, any change of temperature in the outer shell would be more slowly communicated to the inner shell through an air chamber than through brickwork.

II.—DESCRIPTION OF THE ILLUSTRATIONS.

We have first two vertical and sectional elevations of the Clark and Marshall stacks, the first half showing an external elevation, and the other half showing a vertical elevation and section combined, giving at a glance the interior arrangement of the shells, flues, and ribs, and foundations.

In this vertical elevation the foundation of the Marshall is shown as it now stands, but the foundation of the Clark is shown in one of its transitional stages, it being neither the original design nor the last.

The vertical elevation of the Marshall above grade is just as it was planned, but not as executed, the base in the executed design being one foot and half an inch less in diameter, and a proportionate decrease ensuing all the way up to the chapter, and one foot and six inches lower in height.

Fig. 1 is an enlarged elevation of the Marshall chapter. The recesses are about 4 in. in depth, 4 in. wide, and 3 ft. from top to bottom.

Fig. 2 is a horizontal section on the line A—B (see Fig. 3), showing the relation of the ribs to the external and internal shell.

Fig. 3 is a vertical elevation of the base of the Marshall shaft, showing the principal opening for the flues from the furnaces, its dimensions, and distance from grade.

Fig. 4 is a vertical elevation of the Marshall foundation as originally planned, but owing to the character of the ground and change of dimensions, the stone was replaced by brick and the bed of concrete made deeper and contracted in area.

Fig. 5 is a transverse section of the Clark stack at the top of the *vena contracta*, showing its throat, the dimensions at that point, and the depth of the outer shell.

Fig. 6 is an attempt to show the original and final design of the Clark stack foundation. The full line, showing a width of 24 ft. and a depth of 6 ft., incloses what was originally designed to be the foundation. The broken line, 28 ft. by 12 ft. 3 in., is the final design. The irregular masses marked C and D were put in after the chimney proper was erected, and may be technically described as grouted concrete, or, in other words, the refuse from the cement barrels. Some cement that was rejected for the chimney proper, brick bats, broken stone, etc., were shoveled into this part of the excavation and grouted, the whole forming a solid mass, and after the lapse of several years is apparently in good condition.

The diagrams serve to show the thicknesses of the shells at various points, and are arranged in sequence, beginning at the chapter and going down to grade.

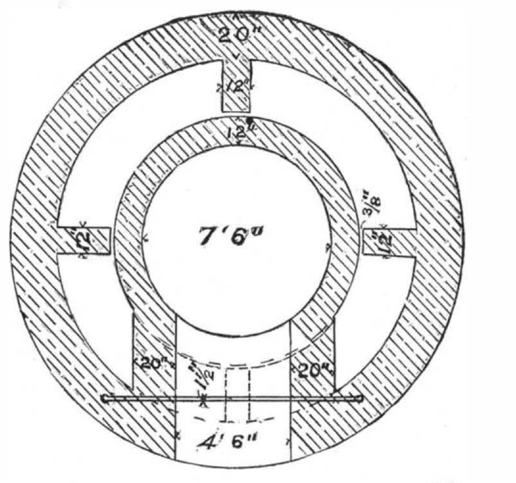
Fig. 7 is a vertical elevation and section combined of the Clark stack, showing dimensions and structure of iron cap recesses and ornament.

III.—QUANTITY CALCULATION OF THE MARSHALL STACK.

The Marshall stack was built for Marshall & Company, linen thread manufacturers of Leeds, England. The work was done by the Flynt Building and Construction Co. It was begun in July and finished in August. It was originally designed to be 17 ft. 7½ in. in diameter, but was finally reduced to 16 ft. 6 in. The drawings show the structure according to the original design. Beginning at the grade line, the excavation was carried down eleven feet in the form of a circular pit twenty-four feet in diameter. Water level was struck at the bottom of the excavation; no soundings were taken. The soil is similar to that at the Clark stack. In the leveled bottom of the pit, a circular bed of concrete, three feet in depth, was laid to the full diameter of twenty-four feet. On this bed the brickwork was laid to grade, battering from twenty-four feet at the bottom to sixteen feet and six inches at grade. Operations were suspended for two weeks, in order to give the concrete and brick foundation time to set. The opening at the discharging mouth of the chimney was first designed to be 7 feet 6 inches, as shown in the general drawings, and in accordance with which the horse power capacity has been calculated; but in order to conform to the construction required by the contraction of the base, the opening was narrowed to 6 ft. Its height from grade to top of cap was designed to be 176 ft. 6 in., but this was reduced to just 175 ft. The chimney as constructed is reported to contain about three hundred and thirty thousand brick, and to have cost about seven thousand dollars. The face brick are Wood & Keenan's A. W. K. Haverstraw brick, and the backing brick are the B. J. A. brand of the same firm. No fire brick has been used in the structure. In regard to the load on the foundations, the following estimate has been made. The figures are approximations. One thousand Haverstraw brick, size $8 \times 3\frac{1}{2} \times 2\frac{1}{4}$, laid in Portland cement mortar, will weigh 5,412 lb., hence $330{,}000 \times 5412 = 892$ tons. The concrete bed weighs (140 lb. per cubic foot) 95 tons, making the total weight 987 tons. The area of the foundation bed is 452·389 square feet, and the pressure upon this foundation, therefore, is 1·97 tons per sq. ft. The ensuing calculation pertains to the Marshall stack as designed originally, with a diameter at the base of 17 ft. 7½ in. The outer and inner shells have been determined separately, and two and one-half per cent. allowed for waste. Taking up the outer shell first, beginning at the chapter, we are to regard it as an inverted truncated cone with a cylindrical flue opening. For the sake of the builder and contractor, who may wish to know how such matters are calculated, we give the work for the chapter, the first section of the outer shell, and one of the ribs in full. The method of calculating the remaining sections will be indicated and the results given; the factors of all the shells and ribs are to be found in the diagrams.

In the diagram drawings, let Fig. A represent the vertical section of the Marshall chapter. The external diameter at the top is 12 ft. 9 inches, at the bottom it is 10 ft. 4½ inches. The diameter of the cylindrical flue is 7 ft. 6 inches. Altitude of the figure, 8 ft.

FIG 2. SECTION ON A-B



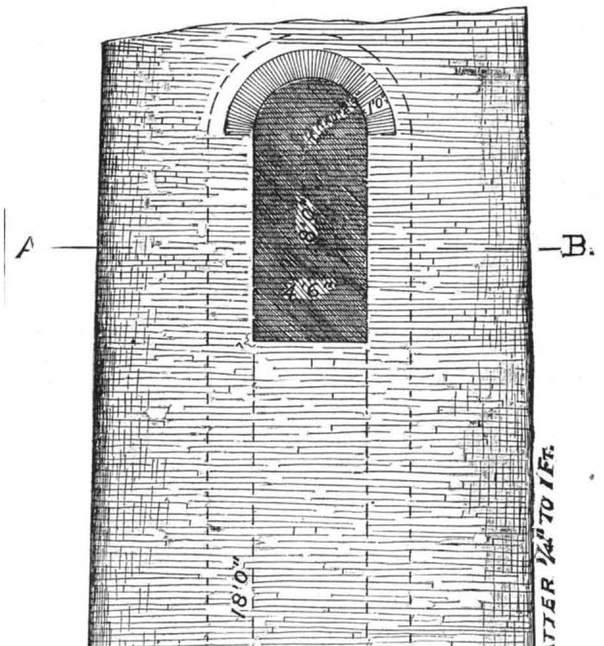


FIG. 3. VERTICAL ELEVATION.

To determine the volume of the chapter, supposing it to be a solid body, we note that it is the truncated fustum of a cone; it is to be obtained by adding together the squares of the diameters of the upper and lower base and the product of the two diameters; multiply this sum by 0·7854 and this product by the height, and divide this last product by 3.

To shorten the work, we shall use the conventional signs to indicate operations, and write results. Reduce all dimensions to decimal parts of a foot. 12 ft. 9 in. =12·75 ft., 7 ft. 6 in. = 7·5 ft., 10 ft. 4½ in. = 10·375 ft. After the volume of the fustum is obtained, the volume of the cylindrical flue is calculated, and subtracted from the fustum; the remainder is the shell of brickwork which constitutes the chapter. To obtain the volume of the cylindrical flue referred to, we find the area of the base, which is the lower cross section of the flue, and multiply this area by the height of the flue. The operation is as follows. See the diagram A.

$$(10·375)^2 = 107·6406$$
$$(12·75)^2 = 162·5625$$
$$(10·375 \times 12·75) = 132·2812$$
$$402·4843$$

$$\frac{402·4843 \times 0·7854 \times 8}{3} = 842·961 \text{ cu. ft.} = \text{volume of frustum.}$$

The area of a circle whose diameter is 7·5 is = to 44·1786. 44·1786 × 8 = 353·429 cu. ft. = volume of cylindrical flue, hence 842·961 cu. ft. minus 353·429 cu. ft. = 489 532 cu. ft. = volume of brick shell of the chapter. This is approximative, because the offsets and recessions were not summed up, and it is near enough for all practical purposes.

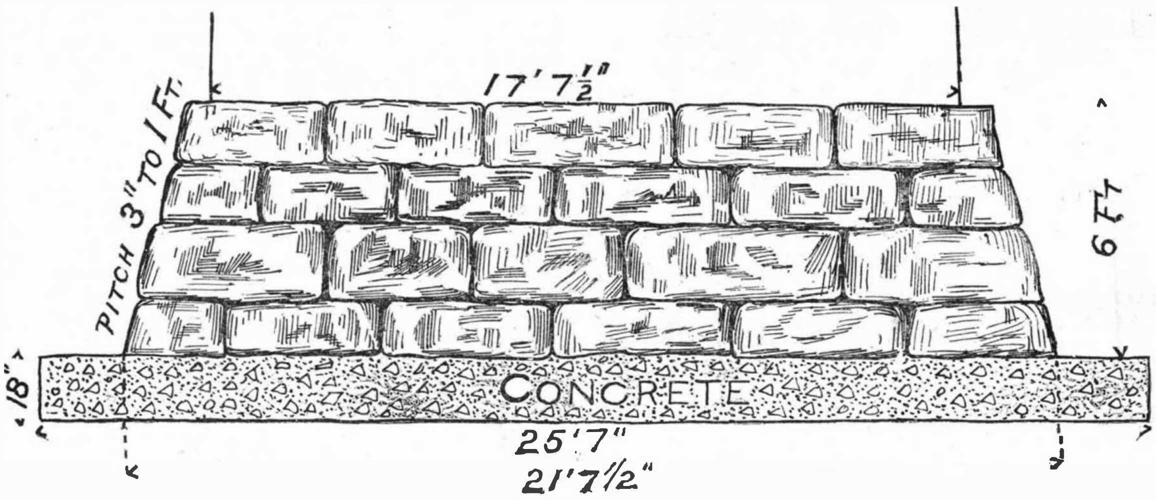


FIG 4. FOUNDATION AS FIRST PLANNED.

To determine the first section of the Marshall chimney proper, see diagram B. It is perceived that the supposed vertical section shown in the diagram is the frustum of a cone the same as the chapter; the flue, however, is also a frustum of a cone. Subtract the inner frustum from the outer frustum, and the contents of the outer shell are obtained. By diagram B, we see that the inner frustum is 8 ft. 4½ in. diameter at the top, 10 ft. 4 in. at the bottom, and the altitude is 42 ft. Pursuing the same course as above, we have volume of entire frustum =4264·1787 cu. ft., and the flue frustum is 2896·784 cu. ft.; the difference is 1367·3947 cu. ft., which is the volume of the brick shell. The volume of C obtained in the same way is 3634·73 cu. ft., and of D is 3853·07 cu. ft. Total volume of outer shell including chapter is 9344·72 cu. ft.

The ribs of the outer shell are five in number, and are denoted by the letters E, F, G, H, and I. To determine E, we first decide what kind of a geometrical figure it is. The face on which the letter is marked is parallel to the face opposite it; it is a six-sided figure, the top and bottom faces are parallel to each other; there are two faces, however, indicated in projection by the two upright lines which bound the face of E, and which are not parallel to each other nor are the planes in which they lie parallel to each other; the figure may then be called the frustum of a wedge, or a prismoid. The prismoidal formula reads thus: The volume of a prismoid is equal to the sum of the areas of the upper and lower faces, and four times the area of the middle section between the top and bottom faces. Multiply this sum by one-sixth of the perpendicular distance between the top and bottom planes. The dotted arrows in the diagrams indicate the uniform widths of the ribs; the figures adjoining them, the depth of the ribs at the bottom and top. There are four ribs to each section shown in the diagrams, or twenty in all.

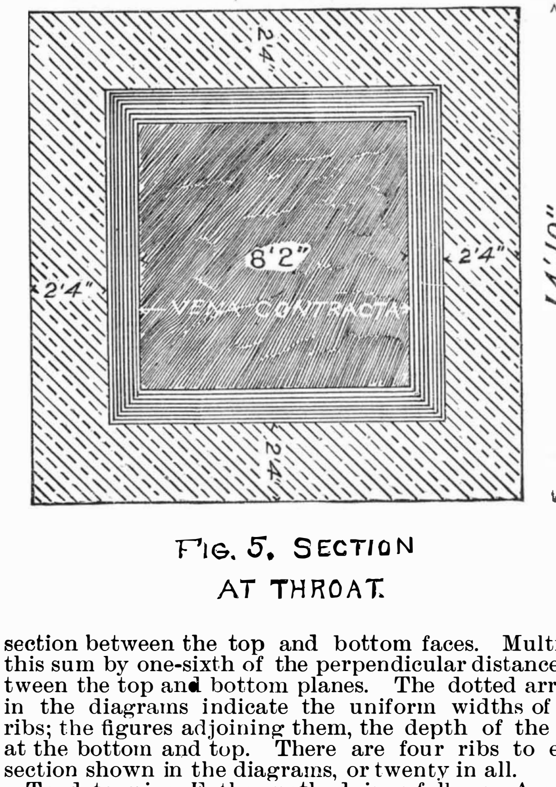


FIG. 5. SECTION AT THROAT.

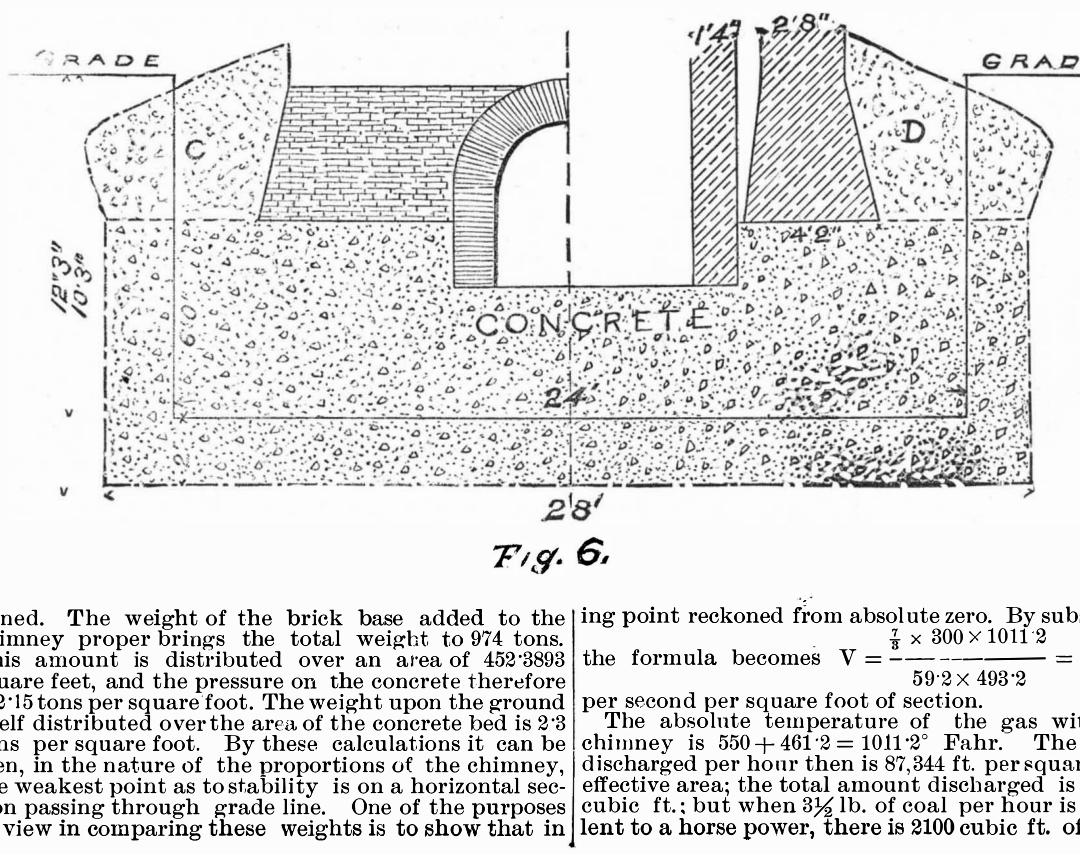


Fig. 6.

To determine E, the method is as follows: Area of top face = 12 in. × 1 in. = 12 square inches; bottom face 8 in. × 12 in. = 96 sq. in.; 96 + 12 = 108 ÷ 2 = 54 sq. in. = area of middle section; 54 × 4 = 216. Sum of areas = 324 sq. in. ÷ 144 = 2·25 sq. ft.; 28 ÷ 6 = 4⅔ × 2·25 = 10·5 cu. ft.; but as there are four such ribs, the volume of all the ribs in E becomes 42 cu. ft., and in the same way F = 32 cu. ft., G = 165 cu. ft., H = 110 cu. ft., and I = 374·16 cu. ft.; total volume of ribs = 723·16 cu. ft.

To determine J, the volume depends upon the contents of two cylinders. The inner cylinder subtracted from the outer cylinder will leave the brickwork shell. Reduce all dimensions to decimal parts of a foot as before, thus 8 ft. 2 in. = 8·1667 ft. and 7 ft. 6 in. = 7·5 ft.; hence $(8·1667)^2 \times 0·7854 \times 30 = 1571·464$ cu. ft. = outer cylinder. Inner cylinder, which is the flue space, is obtained in the same way; $(7·5)^2 \times 0·7854 \times 30 = 132·5358$ cu. ft., hence, by subtraction, the volume of the brick shell of J is equal to 246·106 cu. ft. Pursuing the same method with regard to K and L, their respective contents are found to be 1163·060 cu. ft. and 2002·77 cu. ft. The base is a solid cylinder, and is equal to 313·531 cu. ft. Total volume of inner shell and base above grade line is 3725·521 cu. ft. Total volume of both shells, ribs, chapter, and base above grade line is therefore 13,792·35 cu. ft. In a cubic foot of solid masonry, with one-quarter inch joints, using North River brick (8× 3⅜ × 2¼), and allowing 2½ per cent. for waste, the results obtained are as follows: 13,792·35 × 22·34 = 308,121·099 ÷ 0·975 = 316,021 brick above grade. The calculations just made are based on a much larger stack than was actually built. To arrive at the total amount of brick in the chimney, the brick used in the foundations must be added to those just obtained, and the amount will be calculated further on. To arrive at the weight on the foundations, as everything below grade line is considered foundations, it would be safe to take the weight of the chimney as the weight of 308,121 brick and their mortar. Thus, the area of the cross section of grade is 243·9765 sq. ft., and suppose all of the weight above this plane to be concentrated with this area, the weight will be nearly 13,792·35 cu. ft. × 118 lb. = 814 foot tons; this divided by 243·9765 = 3·33 tons per square foot at grade. To find what the pressure would be on the concrete base, the contents of a solid cone frustum must be calculated. The diameter of its upper base is 17 ft. 7½ in., the same as the diameter of the chimney at grade; as the joints here coincide, the diameter of the lower base is 24 ft., because the lateral face of the frustum slopes to the exact transverse dimensions of the concrete bed. The height of this frustum is 8 ft.; its volume is found to be 2742·9 cu. ft. The number of bricks in the foundation, then, is approximately 61,276, and the weight in round numbers 160 tons. Conceive a prismoid whose upper and lower bases are squares, one side of which at the top is equal to the diameter of the upper base of the cone frustum, and one side of which at the bottom is equal to the diameter of the lower base of the cone frustum, and whose altitudes are equal, using the same figures for the prismoid that are used for this cone frustum, and it is found that it will require 10,000 more brick to lay the prismoid than the cone frustum.

The total weight of the chimney can now be determined. The weight of the brick base added to the chimney proper brings the total weight to 974 tons. This amount is distributed over an area of 452·3893 square feet, and the pressure on the concrete therefore is 2·15 tons per square foot. The weight upon the ground itself distributed over the area of the concrete bed is 2·3 tons per square foot. By these calculations it can be seen, in the nature of the proportions of the chimney, the weakest point as to stability is on a horizontal section passing through grade line. One of the purposes in view in comparing these weights is to show that in general, in a symmetrical chimney, the joint of least stability may lie in the plane where the base and chimney proper coincide, and in the writer's opinion a chimney should be so proportioned, and its relation to all its parts should be such, that the joint of least stability will be found in this coincident plane.

The Marshall stack was designed to have a capacity of 1,500 horse power, but has not been tested yet as to capacity. They have a grate area in use equal to 1,200 horse power. This capacity was based on nearly the same grate area as the Clark. In the former hard coal, and in the latter soft coal, is used to make steam. A great advantage in the use of hard coal over soft is a lower percentage of soot formation, but, on the other hand, a greater amount of water is evaporated per pound of fuel when soft coal is used.

In both stacks the brick are laid in cement mortar, as the engineers believe that lime mortar is readily attacked and crumbled by constant contact with sulphurous and sulphuric vapors and creosote from the fuel. The temperature in the stacks is so low that the cement is not affected.

In the Marshall stack no provision is made to prevent the accumulation of soot, dust, and the products of combustion betwen the two shells. The top of the inner shell should be covered by a projection of brick or by an iron plate. The Clark mills are using double-condensing Corliss engines, and under favorable circumstanees have developed 1 horse power to 2·4 lb. of coal burned. The boilers are of the horizonal tubular type, by the Hartford Steam Boiler Co. The Marshall mills are using compound tandem engines, and expect that a horse power will be developed by something less than 2 lb. of fuel.

The Clark boilers evaporate about 11½ lb. of water to one pound of fuel; the feed water is heated to 150° or 200° Fahrenheit by Green's economizers before entering the boilers.

To the courtesy of Messrs. R. Kerr Clark, R. K. McMurray, Messrs. Lockwood and Greene, and the Flynt Building and Construction Co. the writer is greatly indebted for the drawings, details of construction, estimates of cost, and other information which they cheerfully furnished.

IV.—HORSE POWER CAPACITY.

The capacity of a chimney may be measured by the draught expressed in a given period. Various formulas are in use to determine this quantity, but two of them will be referred to, as all of them are approximative, and must be considered indicative rather than positive. The real capacity must be determined by experiment. The maximum capacity may be determined by the following formulas:

$$\text{(X.)} \begin{cases} H = 3·33\, E \sqrt{h} \\ E = A - 0·6 \sqrt{A} \end{cases}$$

In which H = horse power capacity; E = effective area of the chimney's mouth; h = the height of the chimney proper; A = actually area of mouth in square feet.

Suppose it is required to find the maximum horse power capacity of a chimney which is 192 ft. above grade and whose actual area at the top is 64 square ft. Then $E = 64 - 0·6 \sqrt{64} = 59·2$, and $H = 3·33 \times 59·2 \sqrt{192}$ then H = 2,732 horse power, the maximum capacity.

To find the economical working capacity we suppose the following conditions to hold good: Let 3½ lb. of coal per horse power be the desired consumption, and the temperature of the gas within the chimney to be 550° Fahr. above that of the surrounding air. Let 2⅓ lb. of coal be consumed per second, and 300 cubic ft. of air at 32° Fahr. be the volume of air supplied per lb. of fuel, and the effective area of the chimney mouth be 59·2 square ft., the same as before, then we may use the following formula of Prof. Rankine:

$$\text{(Y.)} \quad V = \frac{W \times q \times t}{a \times V^1}$$

In which V = velocity of the current in the chimney in feet per second; W = the weight of fuel consumed in pounds per second; q = quantity of air in cubic feet supplied per pound of fuel and at a temperature of 32° Fahr.; t = the absolute temperature of the gas discharged by the chimney; a = the effective area of outlet in square feet; and V_1 the temperature of the freezing point reckoned from absolute zero. By substitution the formula becomes

$$V = \frac{\frac{7}{3} \times 300 \times 1011·2}{59·2 \times 493·2} = 24·24 \text{ ft.}$$

per second per square foot of section.

The absolute temperature of the gas within the chimney is 550 + 461·2 = 1011·2° Fahr. The amount discharged per hour then is 87,344 ft. per square foot of effective area; the total amount discharged is 5170764·8 cubic ft.; but when 3½ lb. of coal per hour is equivalent to a horse power, there is 2100 cubic ft. of gas dis

charged per horse power; hence $\frac{5170764 \cdot 8}{2100} = 2462$ H. P. or the effective working horse power of the chimney, and the result agrees closely with the tested capacity of the Clark chimney.

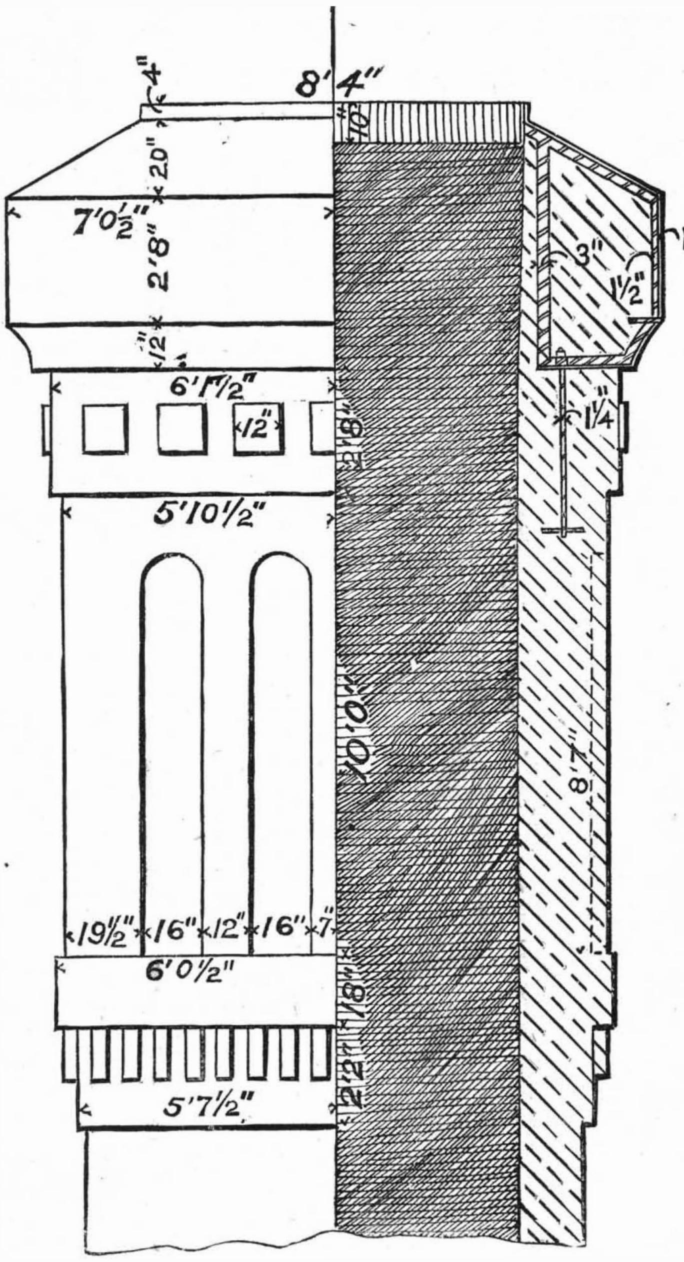
Using the same formulas and same conditions for the Marshall stack, we have $V = \frac{1 \cdot 4583 \times 300 \times 1011 \cdot 2}{40 \cdot 191 \times 493 \cdot 2} = 22 \cdot 31$ ft. per second. $22 \cdot 31 \times 3600 \times 40 \cdot 191 \div 2100 = 1537$ H. P., which is its economical effective horse power. By formula X the maximum horse power is found to be 1769.

The Clark stack is using what is known as the "Cumberland" soft coal from Maryland.

V.—ARCHITECTURAL TREATMENT.

It is admitted that the architectural treatment of a chimney is of secondary importance, and it may be a matter of opinion whether it is even that, but if it is, then something can be said as to the manner of this treatment. In regard to the effect, for example, of the

FIG. 7. VERTICAL ELEVATION AND SECTION OF CHAPTER.



two chimneys under discussion, it may be said of the Clark that its general outline is good. It stands on a level plateau, between two large mills, high enough, however, above them to escape being dwarfed by the association, and it may be that their horizontal extension, great in comparison to their height, adds something to the chimney's real height. It has two striking disadvantages, one of which is attendant upon every stack of its kind, and that is the impression of a breadth too great for its batter when viewed diagonally. The other is the heavy appearance of the chapter in contrast to the total height of the chimney, and not to its lateral extension.

The recesses of the arcaded chapter are not deep enough to obtain the proper intensity of shade, a remark which will apply equally well to the recesses of the Marshall. Deeper shades in the arcades and longer shadows from the modillions would have a tendency to lighten the entire effect of the chapter.

In the Marshall stack, the outline is not so sharply defined against the sky, because of its convex surface. The shadowy uncertainty of its contour makes it picturesque. From no point of view can the stack be seen without that delicate balancing of light and shadow which baffles all analysis. A chimney with such parts may have expression, and this may be found perhaps in the conjunction of two circumstances. Its utility is unquestioned; if added to this it commands instant admiration, the reason must be sought for in the universal love of beauty united to truth.

In one sense a chimney may be considered as a monument to industry. Wherever it may be seen, it is the evidence of energy transformed into work. In the case of dismantlement, it is the last fragment to be torn down; in the event of a conflagration, it is the last block of masonry to fall, and who ever saw a chimney fall without a sigh of regret? Generally, it may be said, it alone outlives its usefulness, unless it be unseemly to commemorate the industry which gave the chimney birth.

In the very nature of things, a chimney cannot be modest and hang its head below surrounding buildings; and if it must tower aloft and outline its face or form against the sky, it should be made worthy of the commanding position it fills. Any prominent object erected by man should be shapely, well arranged, and consistent with the principles of design. It requires more skill to originate a positively ugly stack than to build a graceful one. The slender obelisk form of a chimney naturally lends itself to architectural treatment, and who would be so bold as to deny the charm that lurks about a chimney whose faces are clothed by "shadows fringed with light," where "form is substance, substance form," and grace the hood of beauty.

VI.—REFERENCE TABLE OF DIMENSIONS.

	Marshall.		Clark.	
Heights.	Ft.	In.	Ft.	In.
Above grade	175	0	192	0
Total, including foundation.	186	0	204	3
Of chapter	16	6	22	0
From grade to chapter	158	6	170	0
Batters	$\frac{25}{100}$ in. to 1 ft.		$\frac{22}{100}$ in. to 1 ft.	
Diameter or Widths.				
External at grade	16	6	17	0
External at foundation	24	0	19	0
External at chapter	10	9	10	9
Flue at grade	6	0	8	2
Flue at mouth	6	0	8	0
Outer Shells.				
Thickness of chapter at lowest point	1	0	1	4
Height of shell	42	0	18	0
Thickness of second section	1	4	1	8
Height of same	70	0	36	0
Thickness of third section	1	8	2	0
Height of same	55	0	38	0
Thickness of fourth section			2	4
Height of same			42	3
Thickness of fifth section			2	8
Height of same			35	9
All recessions	0	4	0	4
Inner Shells.				
Thickness of first section	0	4	0	8
Height of same	30	0	18	0
Thickness of second section	0	8	1	0
Height of same	68	0	22	0
Thickness of third section	1	0	1	4
Height of same	75	0	20	0
Base proper, height	2	0	4	4
Foundation depth below grade	11	0	12	3
Weights.	Tons.		Tons.	
As erected	987		2,187	
Brickwork	892		1,624	
Concrete	95		563	
Load on concrete foundation per square foot	1·97		2	
Load on ground per square foot	2·18		2·8	
Horse Power.	Marshall.		Clark.	
Working capacity as planned	1,500		2,400	
Original available capacity	1,769		2,732	
Maximum power as executed.	1,105		2,732	
Cost.				
Per horse power as planned, working capacity	$5	23	$5	83
Per horse power as executed	6	33	5	53
Total, as erected	7,000	00	14,000	00

THE RAFFARD SYSTEM OF BAND WHEELS.

M. RAFFARD in the construction we are about to describe, proposes to balance as well as possible the strains upon the bearings of such arbors as are to be driven at high angular velocity. The arrangement which he uses is designed to reduce to a minimum the work of the wasteful resistances and to diminish the portion, always too great, of the work of the motor which they absorb.

In transmission between parallel arbors a high tension is generally given at first to the belt as necessary to prevent it slipping on the band wheels. This initial tension is preserved on the average through the system while the movement continues, but is unequally divided between the driving and driven pulley. It causes a disproportional pressure on the journals, and produces a friction proportional to the tension developed.

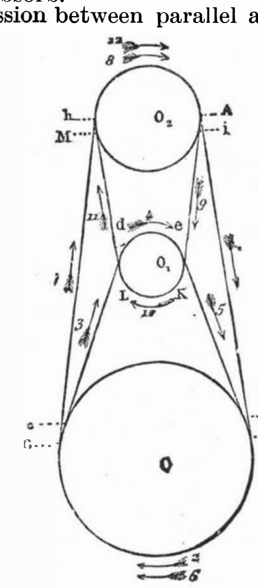


FIG. 1.

M. Raffard, it may said, doubles the transmission by supplementing the two original arbors by a third and auxiliary one. Suppose, for example, referring to Fig. 1, that the movement of the arbor, O, is to be transmitted to the parallel arbor, O_1. M. Raffard adds to the system a third arbor, O_2, parallel to the two first, and lying in the plane of the axes of O and O_1, and above them both as represented.

Two pulleys with double grooves, whose radii are determined by the angular velocity it is proposed to develop, are mounted on the three axes, O, O_1, and O_2,

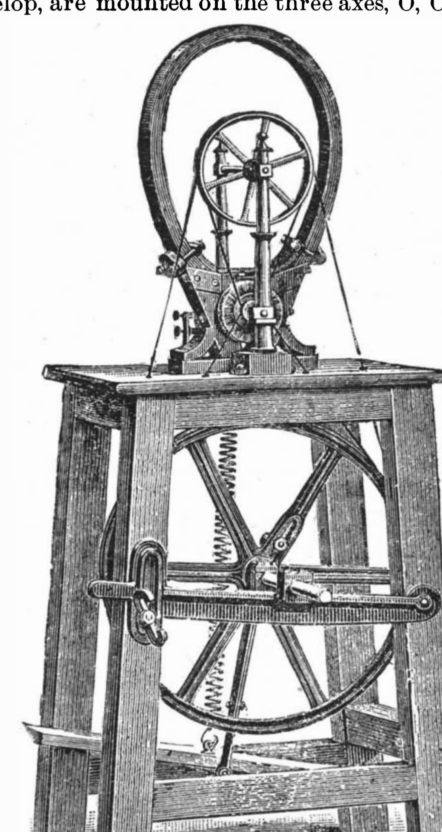


FIG. 2.

and a single endless cord or belt connects them all together, lying in lines tangential to the three circles taken in pairs, following the lead denoted by the following letters:

A b c d e F G h i K L M A.

In the notation which we have adopted here for denoting the different points of contact of the six tangents, the large letters denote the grooves of the pulleys situated in front of the plane of middle section parallel to the plane of the paper, and the small letters those situated behind the same. It is at once evident,

from the succession of the large and small letters, that the cord changes its plane between A and b, between e and F, between G and h, and between i and K. In these courses it shifts from front to rear of the middle section, while it keeps the same plane in going from c to d or from L to M. This being understood, if the wheel, O, is moved about its center in any determined direction, the transmitted movement will turn the wheels, O_1 and O_2, and will be transmitted from O_2 again to O_1. The tensions exerted upon the wheel, O_1, will become sensibly balanced, and this wheel will turn without any appreciable friction between its journals and their bearings. As much cannot be said for the

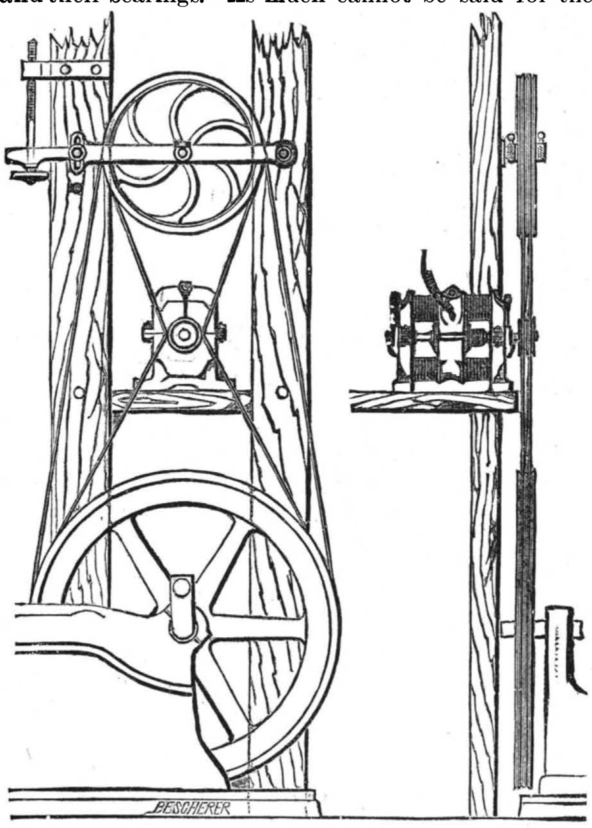


FIG. 3.

wheels, O and O_2, in whose case the tensions are added instead of balancing. Hence considerable pressures are developed upon the journals of these two rotating masses. At first it would seem that the arrangement adopted is no improvement, as it seems only to transfer to the bearings of O and O_2 the strains otherwise falling on the intermediate shaft. But the initial tension required to insure the transmission by belt between two band wheels on parallel axles depends principally on the amplitude of the arc embraced by the belt upon the circumferences of the two wheels. These arcs being doubled in the arrangement due to M. Raffard, a lower initial tension can be adopted without danger of impairing the transmission, and on this account alone the friction on the journals of O and O_2 will be considerably reduced. Moreover, the work absorbed by the friction of journals depends not only on the friction developed, but still more on the number of revolutions completed by the axle in a given time. From this point of view the friction of the fastest turning journal should properly be reduced, and be transferred to a journal of slower rotation. Finally, by the new arrangement, a diminution of passive wasteful resistances and of the work absorbed by them is attained, and the arbor, O_1, is placed in a position of equilibrium that suggests additional incidental advantages. The Breguet company have adopted this mode of transmission for communicating motion to the ring armatures of laboratory magneto-electric machines, which turn at 1,800 to 2,000 revolutions per minute (Fig. 2). Besides these cases, it has only been applied to small machines. On large ones it seems hardly probable that it would give as good results.

Nevertheless, the Breguet company have used it to transmit 100 kilogrammeters per second, and M. Reckenzaun uses it to drive dynamos from a four horse power gas engine, and has in one case used it for one of eight horse power.—*Chronique Industrielle.*

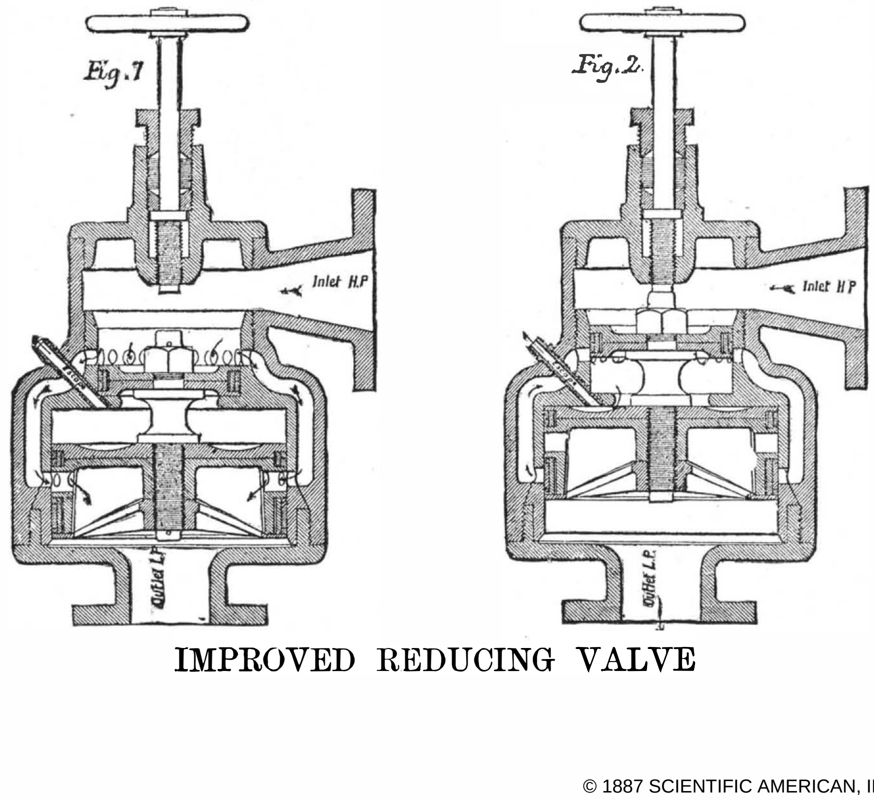
IMPROVED REDUCING VALVE.

CONSIDERING the great demand for an efficient steam reducing valve, now that high pressure steam is rapidly coming into use, there is a special interest in the two sectional engravings we publish from *Engineering*, of such a valve, by Mr. J. R. Fothergill, superintending marine engineer, of West Hartlepool. This valve has been applied with most satisfactory results, particularly in connection with steam steering gear, the severest of all tests.

In a steamer on which this valve has been fitted, the steam is reduced from 140 lb. boiler pressure to 50 lb. There are two other valves on board this steamer, one to the steam jackets and the other to the winches, and the chief engineer's report is identical with the captain's, particularly as to no accumulation of pressure. The same satisfaction is also given in other steamers having boiler pressures of 160 lb.

By reference to Figs. 1 and 2 the construction of the valve will at once be understood. The valve itself may be said to consist of two differential pistons, whose areas are to one another as the difference of pressure required. As steam from the boiler enters the valve the small piston is forced against the stop (see Fig. 1), and the ports opened for the passage of steam as denoted by the arrows. When sufficient steam has passed to give the required pressure, the large piston is then forced against the stop (see Fig. 2), and thus the ports at both ends are closed to the passage of steam, but it will be noted the small piston travels past the ports, leaving them partially open, establishing a communication between the steam passage, the body of the valve, and the atmosphere by way of the escape pipes. Thus should there be any leak past the pistons, accumulation of pressure cannot take place, for such leakage would at once escape to the atmosphere as above described and shown by the small arrows in Fig. 2.

By screwing down the wheel at the top of the valve, the small piston is forced and held against the stop, opening a free communication through the valve for the use of full boiler pressure, or allowing the steam to pass through the valve the reverse way, such as from the donkey boiler to the engine room.



IMPROVED REDUCING VALVE

IMPROVED ROPE MACHINE.

MESSRS. WALTER T. GLOVER & Co., of Manchester, have recently introduced certain modifications in their

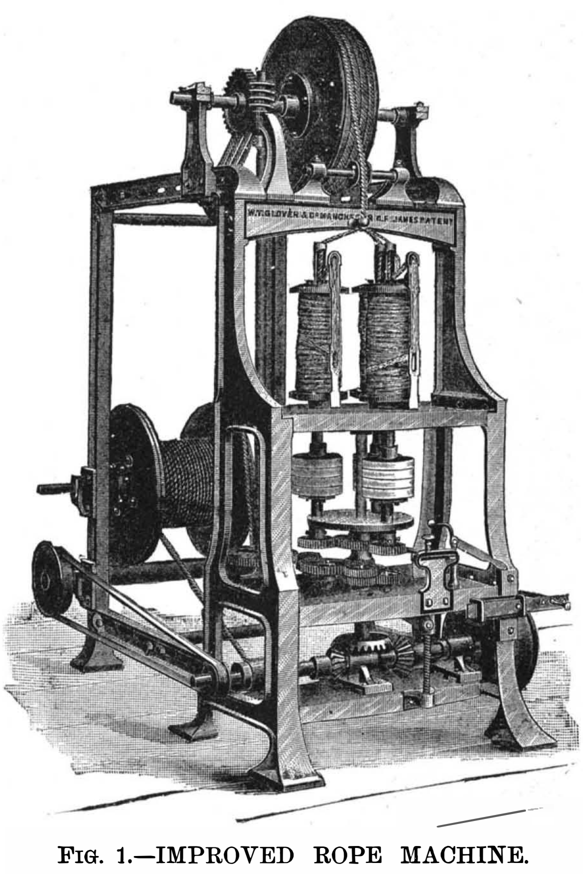


FIG. 1.—IMPROVED ROPE MACHINE.

second size rope machine, by means of which it is now specially adapted for making scroll and rim banding for self-acting mules. The machine will make any size of banding from ¼ in. to ⅜ in. in diameter, and possesses a special interest for cotton spinners, who are by it enabled to make banding from their own yarn. This machine has one head of three spindles. Each spindle is provided with a self-stopping motion, so dispensing with close attendance; for, under ordinary circumstances, when once set to work with full bobbins, the machine will continue to run without attention until one of the bobbins becomes empty. The stop motion prevents the possibility of its continuing to work with either a slack strand, a broken strand, or an empty bobbin; hence no bad work is made. It will make either hard or soft twisted cords as may be desired, and the change from one to the other is easily effected, being brought about by simply a change of wheels.

The spindle bobbins have 14 in. lift, and will consequently hold a great length of yarn and run a consid-

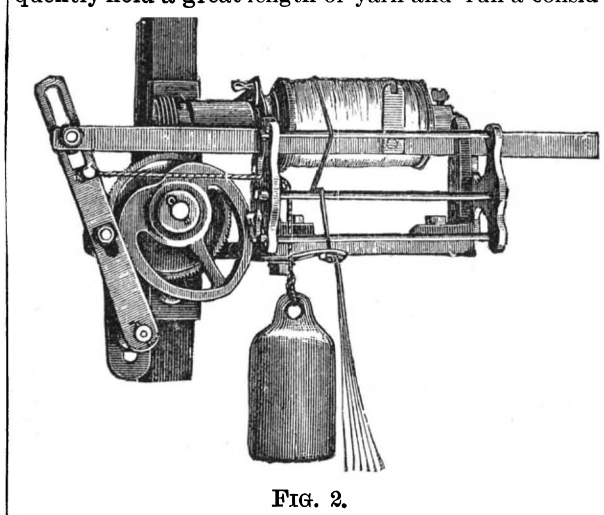


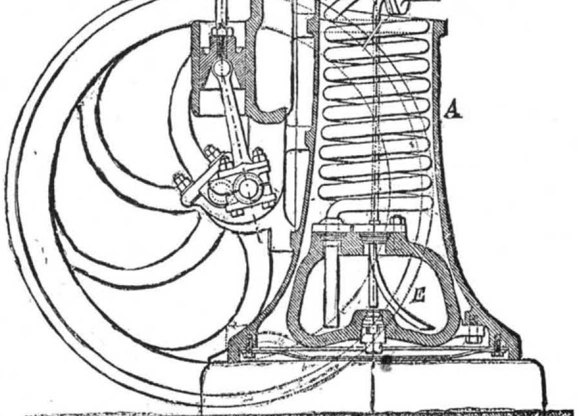
FIG. 2.

erable time without renewal. This is an advantage, as it reduces the necessity of attendance on the machine, and enables it to make a long length of binding at one stretch. "James's" patent spindle is used. By this, among other advantages, there are secured: 1st. Greater facility for threading the yarn through the spindle. 2d. The possibility of threading a greater quantity through a spindle of a given size than under the old system, and hence the production of a thicker cord. 3d. The parts of the spindle work more in unison with each other, and there is, consequently, less wear and tear. When desired, a winding arrangement (Fig. 2) is attached to the machine, by means of which it winds the yarn on to the spindle bobbins at the same time that it doubles and lays. This, which is found to be a very great convenience, is secured at a small additional expense of power, so slightly does it interfere with the ordinary working of the machine. Moreover, it can be stopped without stopping the machine, so that whether the machine be winding or not, it may go on doubling and laying all the same. The special machine which we inspected at Messrs. Glover's works was intended for a cotton mill in India, and a similar machine had recently been shipped to Russia.—*Textile Manufacturer.*

A NEW ICE MACHINE.

THE machine represented herewith was exhibited at the International Exposition of Industrial Arts and Sciences. It was invented by Mr. Fixary, and is based upon the use of liquefied anhydrous ammoniacal gas as an agent for producing cold, through the utilization of the property that it possesses of absorbing, on its passage from a liquid to a gaseous state, sufficient heat to reduce the temperature of the substance upon which the action is exerted to −30° C.

The apparatus consists of a cast iron frame, at the base of which is located the worm, A, of the condenser,



FIXARY'S ICE MACHINE.

and the receiver, E, for the liquid ammonia. It supports at its lower part the freezer, B, with its vaporizing and expansion worm, D, as well as the force and suction pump, G, which is provided with a cooling chamber, H, and a regulating valve, C. This pump is a single acting one, and the ammoniacal gas is admitted to it above the piston only.

The regulating valve, C, in communication with the suction valve and lubricating chamber, H, permits of

maintaining in the latter a certain pressure due to leakages from the piston that accumulate above the oil and form a hydraulic joint around the rod, and thus prevent entrances of air to the interior and leakages of gas from the apparatus.

The oil contained in the chamber, H, lubricates the gas derived from internal leakages, while at the same time it cools them. Finally, when, as a consequence of such leakages, the pressure increases in this chamber, the valve, C, rises, and the gas escapes and is sucked into the pump chamber, where it receives an automatic and continuous lubrication, while at the same time it fills the dead spaces. There is therefore no loss of ammonia whatever, and the machine, once filled with the latter, will operate for years without any necessity of renewing the charge.

The applications of this machine are numerous, and it will be especially serviceable in the smaller industries. The machine is a portable one.—*Chronique Industrielle.*

OIL MILLS.

SOME two years since, the large oil mills situated at the Lower Ordnance Wharf on the Thames, which are now the property of the Union Oil Mills Company, were burnt down, and the design for their re-erection, submitted by Messrs. Rose, Downs & Thompson, of Hull, was accepted. The mills, two in number, form the largest oil-seed crushing establishment in the south of England. The No. 1 mill, of which we give illustrations in Figs. 1 and 2, is designed for crushing linseed, rapeseed, and cotton-seed, and works up 108 tons of either per day of twenty-two hours. The No. 2 mill contains a quantity of old machinery saved from the fire, and is designed for the treatment of rapeseed on the old system of seed crushing, viz., with edgestones and box presses.

The process employed in the No. 1 mill is that introduced into England in 1873 by Mr. Downs and Mr. Thompson, and known as the Anglo-American. As in the roller system of flour milling, the use of stones in breaking up the cells of the seed operated upon is superseded by a system of gradual reduction by rolls. In Fig. 3 we illustrate the type of rolls employed, of which there are six sets in the Union Mills. It will be noticed the construction is much heavier than in rolls used in flour milling, the rolls being five in number. They are of chilled cast iron, and are provided with a spring pressure screw to increase the effect of the upper rolls on the seeds. The whole run in bearings free to slide in the vertical frames, the result being that in each of the four rollings to which the seed is subjected, the pressure increases. The rolls, such as illustrated, are suitable for small oil-seeds, such as linseed, rapeseed, and sunflower seed. For cotton-seed, palm kernels, arachides, and larger seeds, modifications of the surface of the rolls are adapted.

The process of oil-seed crushing adopted in the Union Mills will be best explained by reference to the illustration below. The machinery, it will be noticed, is contained in a one-story building, to the north of which the seed is received and distributed in a four-story warehouse, not shown in our views. The object of the separation of the warehouse and mill is, of course, the reduction of insurance premium on the contents of the former, and the avoidance of the injurious strains to the shafting caused by the unequal weighting of warehouse floors placed above it.

From the disintegrator the seed falls in a continuous stream into the "kettle," F; this is steam-jacketed at the sides and bottom. In it the seed is heated to a temperature of from 160 deg. to 190 deg. Fahr. to facilitate the flow of oil, and at the same time moistened with direct steam. The vertical shaft of the kettle has arms or stirrers at its lower end which agitate the seed and insure equal heating and moistening of the whole, a very important consideration.

From the bottom of the kettle the heated meal is

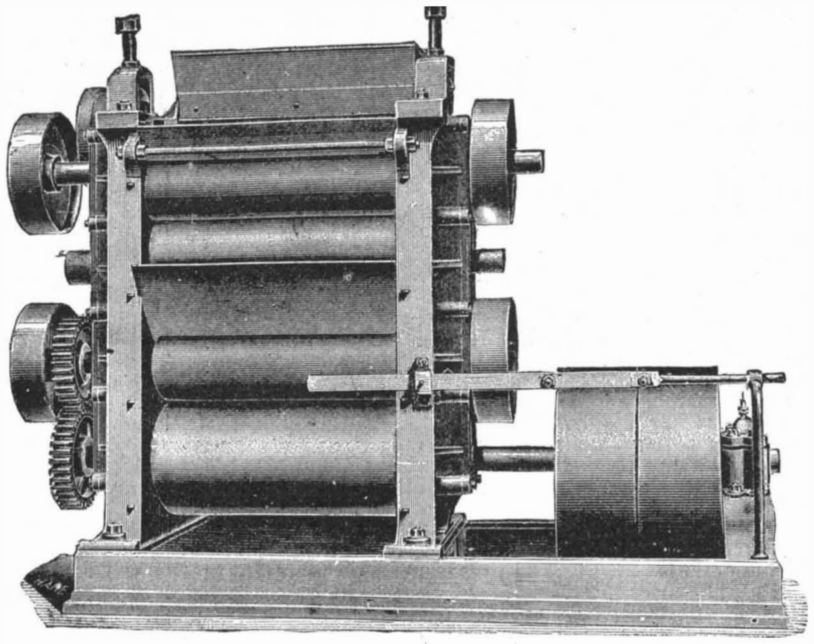
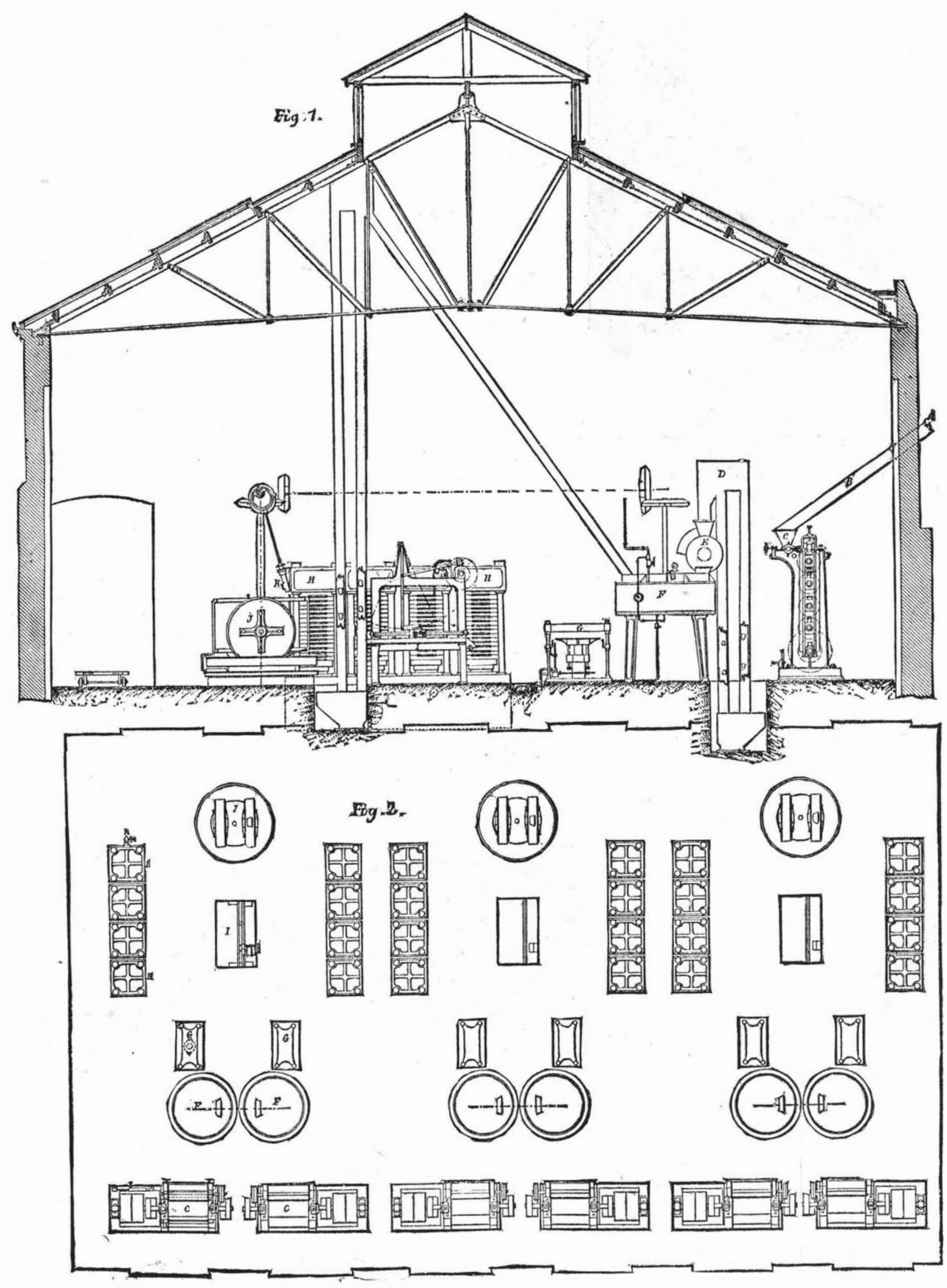


FIG. 3.

OIL MILL PLANT.

In the warehouse are six bins, each communicating with a set of rolls in the mill by a spout, A B. Each bin is designed to hold a supply of seed sufficient for a day's work, so that no night work is required in the warehouse. The seed passing down the spout, B, is regulated by a feed slide and roll, by which it is passed into the rolls, C, previously described; these rolls are driven, by belts, and provided with fast and loose pulleys. From the rolls the seed falls into the box of an elevator D, which discharges it into a disintegrator, E, which further breaks up and mixes the skins of the seeds and the flattened masses of oil cells.



OIL MILL PLANT.

drawn in quantities sufficient for one cake by the "moulder," who works Virtue's patent hydraulic machine, G, illustrated in Fig. 4. The object of this machine is to form and measure the meal required for one cake and to submit it to a preliminary compression, which gives it firmness enough to be placed in the press, reducing its thickness from 3¼ in. to 1¼ in., thus enabling one press to take sixteen or eighteen cakes instead of four to six as in the old process.

The machine consists of a hinged bottomless measuring box, which is filled by the "moulder" from a box drawn across it from the kettle. The box is then lifted, and the mould of seed, covered with a strip of woolen cloth, is pushed beneath the head of the small hydraulic press; this action automatically opens the valve of the cylinder, and the mould of seed is subjected to a pressure which solidifies and compresses it. In the mean while another cake is being moulded. It will be noticed that up to the point of entering the moulding machine the process is perfectly automatic, and is at all times continuous. The compressed mould of seed is withdrawn by the "pressman" at the end of the machine furthest from the kettle. The hydraulic presses used (H) have steel cylinders, and each contains sixteen cakes; they are of very massive construction, and weigh about 8 tons each. They are placed in blocks of four, which stand in a wrought-iron tank placed on the floor to receive the oil and to form a foundation for them. Each group of four presses with its attendant machinery forms a separate unit; the mill contains six of these, of identical design, coupled in three pairs, any of which can be worked on a different oil-seed.

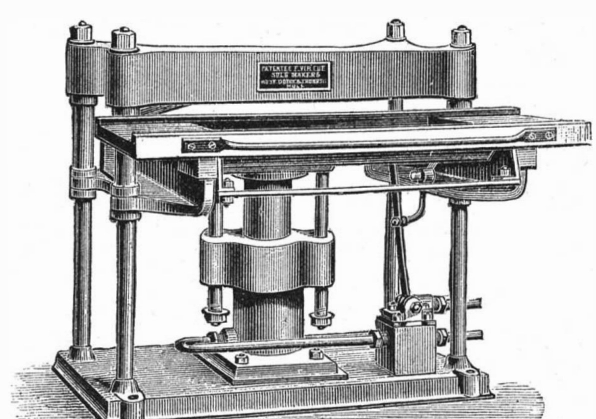


FIG. 4.

The moulds of seed are placed in the press between corrugated malleable plates, and subjected, first, to a pressure of about 2 cwt. per square inch of ram, and then to one of 35 cwt. per square inch. In about twenty minutes the oil is extracted, the quantity in the cakes being reduced to from four to eight per cent., depending on the kind of seed; the ram is then allowed to descend and the cakes withdrawn. When taken from the press, the edges are rough and oily; they are taken by the "parer" to the paring machine, I, which, by means of a reciprocating cutter and gauges, cuts the cakes to size. The machine is double, and serves for two blocks of presses. A screw trough in the center of the machine conveys the parings to a small set of edge-runners, J; these are provided with a double pan, the upper one being perforated. As the parings are ground they pass through the perforations and are swept from the lower pan in the elevators, K; this continuously delivers them into the two kettles, from which they are worked over again. The small stones are also useful in working up mouldy cake or mixing other materials with the seed.

The arrangement by which pressure is given to the presses and moulding machine is of very recent application in oil mills, and has many special features. As the system of accumulators and valves used in crane and dock work would be useless under such heavy pres-

sures as we have named, special regulating valves and other precautions have been employed. In the engine room are two sets of pumps. The small pumps, which supply the high pressure accumulator, are 1⅛ in. in diameter, and the large pumps, which supply the low pressure accumulator, are 3 in. in diameter. All the pumps and connecting piping are of steel.

The accumulators, which also stand in the engine house, are weighted with cast iron circular disks to a pressure of 2 tons and 600 lb. on the square inch respectively. The rams are 3 in. and 10 in. in diameter, and have 10 ft. lift. The weights have no guide frames, each cylinder being turned outside, and the bottom and top weights being formed to fit it, thus making each self-contained on its own foundation. Oil is used in the pumps instead of water, it being found that the valves and leathers last much longer with the former.

The pressure from the accumulators is conveyed into the mill by steel pipes which are laid in a metal trough in the floor of the mill, as shown in the sections; from the low pressure pipe, connections are carried to the moulding machine and to two hydraulic cake hoists, and against each block of presses connections from both pipes are carried to a stop valve with two spindles for each press; by turning one spindle, the low pressure pipe is put in communication with the cylinder. This expresses a large portion of the oil. The "pressman" then opens the high pressure valve, which admits the final pressure of 2 tons to the cylinder.

The pressure is throttled for each press by a separate valve with fine screw adjustment out of the workman's reach, and can be so regulated as to allow of the maximum in the press cylinder being reached in from a minute to half an hour. Each press is fitted with a hydraulic gauge, which checks alike the pressman and the action of these valves.

The oil expressed in the presses falls into the tanks previously mentioned, from which it is drawn by pumps (K) bolted on the end of each block of presses; these force the oil through filter presses placed in the upper part of the buildings, from which it flows by gravitation to the store tanks, or it can be immediately sent away in a clear state in barrels, thus avoiding keeping a large stock of oil for several weeks to allow it to brighten by deposition, as in the old process of seed crushing. The solid matter left in the filters is passed through the edge runners, J, into kettle, F, and again worked up.

The arrangements we have been describing have been worked out with great care, and are the outcome of a large experience in this class of machinery. As compared with ordinary plants of the kind they effect saving in space occupied and in the manual labor of handling materials, while the very perfect extraction of the oil is effected, the cake we are informed having on an average but 7 per cent. of oil remaining in it as compared with the 10½ per cent. usual in cake made in the old way. The use of hair envelopes also is abolished, and a saving effected in the wear and tear of the bagging employed.

The buildings of the mill we have been describing were designed by Mr. E. A. Gruning, and the contract carried out by Messrs. Holland & Hannen. The engine for the No. 1 mill was supplied to the order of Messrs. Rose, Downs & Thompson by Messrs. W. J. Galloway & Sons, of Manchester.—*Engineering.*

THE APPLICATION OF CELLULOSE TO ELECTRIC BATTERIES.

IN English naval practice, the term "cofferdam" is applied to certain tight compartments formed on a ship by a double keel near and below the float water line, and the name is still more absurdly applied to the substances used for filling these compartments. Among such substances there is a preparation of cellulose made from the granular portion of the rind of the cocoanut. This material is in the form of a powder, and has a density of 0·065.

Before being used, it is compressed to a density of 0·133. This substance, which the French, following the English, call "cofferdam," has recently been applied by Mr. P. Germain in the construction of a form of the Leclanche pile that is easily transportable, and can be turned in any direction, withstand blows, and be allowed to fal from a height of five feet without interfering with the operation of the couple.

Fig. 1 represents a longitudinal section of one of these piles. A^2 is a light box made of fir or poplar wood boiled in paraffin and covered externally with an impermeable and plastic cement. At the bottom* of this box is arranged a bed, B, composed of a mixture of equal volumes of peroxide of manganese and granular carbon. Above this there is a plate, C, of agglomerated carbon of high conductivity, and then a second bed, B', like the first. The rest of the box is occupied by a layer, D, of "cofferdam" paste impregnated with a saturated solution of hydrochlorate of ammonia.

This paste is slightly compressed and then leveled, and its thickness is so regulated that it shall slightly exceed the level of the box. Finally, a strongly amalgamated plate of zinc (or rather a series of plates) rests upon the whole, and, exactly covering the cellulose, insulates the latter from the action of the air. The inactive external surface of this electrode is protected from oxidation by a varnish made of bitumen. It now only remains to close the box, T. To do this the cover, E, superposed on the zinc, is screwed to the four sides of the box, and the pressure that it is necessary to exert upon the cellulose, in order to fasten the lid down, suffices at the same time to secure a liquid contact of the active surface of the electrodes with the paste.

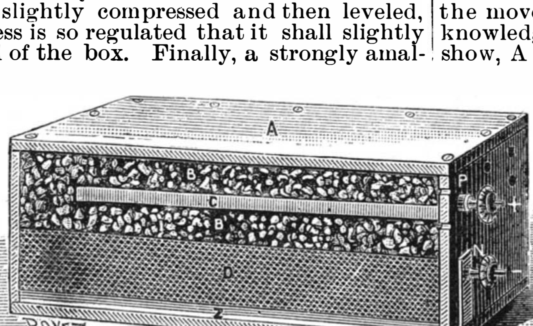


FIG. 1.—CELLULOSE BATTERY.

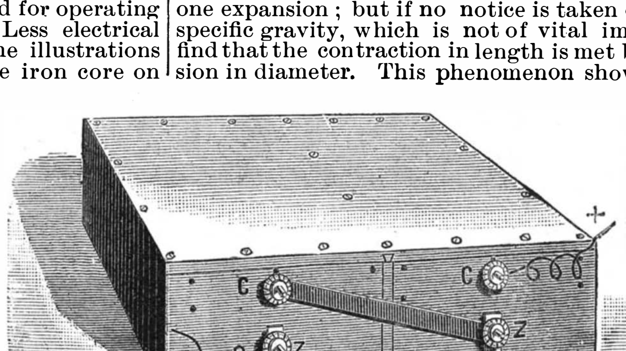


FIG. 2.

* The box is represented in an inverted position.

There are two apertures in one end of the box for the passage of the poles, which are provided with terminals, P and N. The positive terminal is connected with the carbon, and a threaded metallic rod, firmly cemented to the latter, permits of adapting to it a tightening button. The negative element is attached to a tail piece cut in the external zinc plate.

The peculiar arrangement of the zinc electrode is worthy of note. Instead of one very thick plate that it is often difficult to amalgamate in the entire mass, and that allows the mercury to run off easily, there are, as we have stated, several distinct plates of the same size, each or which is amalgamated separately and then superposed one upon the other. The mercury is thus held between the plates, and solders them intimately, and the result is that the amalgamation of the electrode is perfect throughout its entire thickness.

Although, as we have said, the pile will work in any position, it has been found that it is best to place it in the one shown in Fig. 1, that is, with the zinc downward.

The electromotive force of this couple is 1·5 volt. Its resistance, for a given surface, and given space between the electrodes, is no greater than would be obtained with a free liquid instead of the saturated cellulose.

Three sizes of these piles are manufactured. The small and medium sizes furnish from 0·5 to 1 ampere, and are applicable to telegraphy and telephony. The large size, which is so arranged as to furnish from 2 to 5 amperes, according to circumstances, is designed for railway signals, electric clocks, torpedoes, and domestic electric lighting.

The manufacturers often combine two of these couples in a partitioned box, such as shown in Fig. 2.

ELECTRIC BELLS.

THE great interest that was taken in our articles on electric bells, and which has been shown more recently

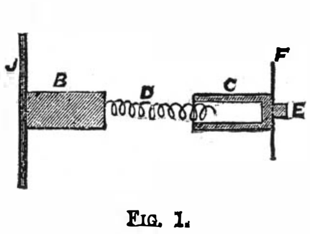


FIG. 1.

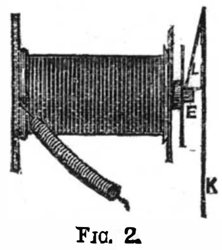


FIG. 2.

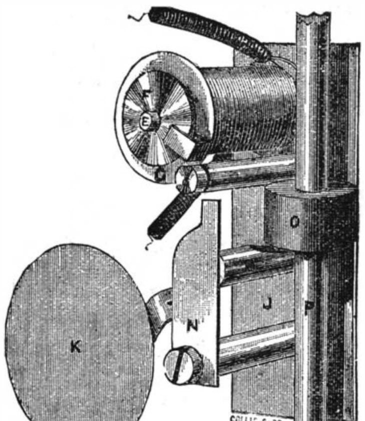


FIG. 3.

in the lectures at the City and Guilds Institute, leads us to think that the following particulars of improvements will be welcomed. The improved designs—actual specimens of which we have before us—are by Mr. Walker Moseley, and refer perhaps more to the indicators connected with the bells than to the bells themselves. The type described and illustrated is that known as the mechanical replacement system. This name is given to a class of indicators which are actuated by electricity only to *expose* the signal or announcement and not to replace it in its normal position, the replacement being by means of mechanical cams, levers, etc., of various types of construction.

The advantages claimed for this class of indicator are (1) That a larger semaphore may be exhibited with a weaker current than would be required for operating the movement in both directions. (2) Less electrical knowledge is required in fitting. The illustrations show, A the solenoid, B one-half of the iron core on which the solenoid is fixed, C the other half of the core, hollow to contain the coiled spring, D, and movable so that the projection, E, opposes the latch, L, and prevents the disk, K, from falling.

The circuit is completed through B, C, G, F, H, J, and it will be observed that the electric current has to produce a force sufficient only to resist the coiled spring, D, which is of silver wire, No. 45 B. W. G. Although the spring is so slight, it appears impossible for any harm to happen to it, because it is so completely inclosed.

The mechanism for replacing the semaphore to its normal position is simple. The vertical bar, P, carries as many flexible rubber cylinders, O, as there are indicators in a vertical line. A portion of pivoted cylinder, M, is cut away, as shown in Fig. 3. The bar, P, being pulled downward, causes M to rotate the cylinder, M, about a quarter circle, which causes the latch, L, to pass over the projection, E (Fig. 2), which springs forward again, and holds up the semaphore until another current is passed through the solenoid.—*Electrician.*

STEEL—FROM THE INGOT TO THE FINISHED TOOL.

By ARTHUR Y. JACOBS, of Sheffield.

THE method and manner of hardening and tempering steel is perhaps the most delicate operation in connection with mechanical art, and is equally as important as the quality and temper; and while each tool requires a slightly different treatment, still there are certain fundamental laws and principles which, if duly and properly observed, will always serve as a guide, and invariably lead to satisfactory results.

I fear my Sheffield friends will think me somewhat presumptuous if, in the first place, I notice a method in general use in that town, and which I think is one that should be, if possible, avoided.

Ingots invariably show on their skin a quantity of small holes—"pin holes," as they are termed in the trade—which vary in quantity and size according as the steel has been properly melted or "killed," or it may be from other causes which neither science nor the "rule of thumb" has yet indicated. These "pin holes," if disregarded, are drawn out with the steel, and take an elongated or longitudinal form in the bar, and are then known as "seams" or "roaks." To obviate these it is the practice, after the ingot has been slightly hammered, or, as it is called, "saddened," to chip with a chisel and hammer those places which are plainly visible, and thereby remove the oxide or whatever extraneous matter is contained in the holes. This being done, the ingot, or rather "billet," is then again placed in the fire, and, with the aid of sand, borax, and other fluxes, a high heat is given, which is technically called a "wash" heat, but is really a welding heat.

This is done for the purpose of sealing or closing up such superficial imperfections as have not been noticed. No doubt the operation serves its intended purpose so far as outward appearance goes, but that it frequently fails is evident from the fact that workmen far removed from Sheffield or other tool steel producing districts are quite familiar with the terms "seams" and "roaks," which they apply to steel that shows the slightest sign of unsoundness, no matter from what cause it may arise.

A very pertinent question may be suggested in connection with this subject, which I will anticipate, viz., How is it possible to detect a "roaky" bar if the skin is clear and sound? I must confess it is very difficult except to those whose business it is to look for such places, but to one who has a thoroughly practical knowledge no very great obstacle should present itself. I have found the following method most effectual. Should any doubt exist as to the presence of "seams" in the bar, heat it to about a tempering heat—that is, "black hot"—then break it, and it will be seen that, although the skin is clear and sound, still these nasty little black streaks are buried in the steel, and the fracture, instead of showing a smooth and regular surface, is interspersed with zigzag lines, which upon a close examination will be found unsound places, corresponding no doubt with the "pin holes" in the ingot. These tantalizing "pin holes" are a source of great anxiety, both to the melter and to his principal. But while I indicate the disease, the remedy has yet to be discovered, and it is with the hope that our scientific friends may make this a subject for investigation that I have dwelt upon it at some length, hoping that they may discover the antidote, and thereby prevent or render unnecessary the taking a "wash heat," which must be injurious to the best kinds of steel, especially those containing a high amount of carbon.

I now come to the hardening and tempering of steel. This, to the casual observer, may appear a most simple operation, and if there was no more in it than appears at first sight, those persons who are practically connected with steel would be relieved of a great deal of anxiety.

It is a well recognized fact that steel, when hardened, decreases in specific gravity and length, and increases in diameter. There are therefore two contractions to one expansion; but if no notice is taken of the loss in specific gravity, which is not of vital importance, we find that the contraction in length is met by the expansion in diameter. This phenomenon shows itself more particularly in steel of high temper, and appears to be regulated by the amount of carbon it contains.

The degree of heat employed for hardening is a most important item. A high temper will harden at a low heat, while steel containing a low percentage of carbon will permit of a much higher heat. If too much heat is given, the contraction in hardening is much increased,

the cohesive or tenacious property of the steel is weakened by the enlargement of its molecules, and the heat which is shut in by the contraction or density of the surface causes an internal expansion too great for the partly *denaturalized* steel to withstand, and the result is a water crack.

This shows how necessary it is for the workman to know something of the temper of the steel upon which he may be engaged, and knowing this, also to be aware of the highest degree of heat that may be employed, so as to retain the entire nature.

Another, and equally important, item is that the steel should be thoroughly and uniformly heated at every stage in its manipulation. If for hardening or tempering it is hotter in one place than another, the expansion must be variable, and necessarily the contraction in hardening will be in close sympathy therewith—that is to say, there must be a higher degree of tension in one part than in another, and the natural result must be that the object hardened will either warp or "skeller," but most likely crack.

Sectional cracks occur, not only from inequality of tension, but also from another and distinct cause. These arise primarily and principally from irregularity in forging. This is illustrated in a very distinct and interesting manner by the raw steel which is made at Hollhammer, near Kapfenberg, in Styria. This steel, as I have already described, is the first result from pig or cake iron, and is drawn down from the lump (or louppe) to bars about one inch square, which, when at a high heat, are plunged into cold water. When the bars are cold they are broken for the purpose of assorting them according to their tempers, and preparing them for the crucible. Those pieces which are highest in carbon always show several fine sectional cracks. If the bar is broken at one of these cracks, the fracture shows all, or nearly all, the varieties of color which appear in letting down or tempering, but in concentric rings. The appearance of the fracture when newly broken is highly interesting, and such pieces are known at the works as "rose" steel. This may be explained as follows: It is the aim and object of the workmen to obtain the maximum of length in each bar at one heat, and as they require no particular finish or regularity in size, the work—that is, the hammering—put upon them is uneven and irregular, and when placed in water they have not the same longitudinal contraction; as in the sport called the "tug of war" the strongest side wins by a strong pull, a long pull, and a pull all together, so does steel which has the greatest amount of contraction pull and tug at its weaker self, and finally pulls itself apart.

It frequently occurs that tools require to be only partly hardened, such, for example, as lathe tools, dies, etc., etc. Very great care is necessary in the heating of these, which should be done in such a manner that the heat thoroughly penetrates to the center of the steel, and should vary in degree from, say, cherry red at the cutting or working part to dark or black red in the other part.

In hardening, it is particularly desirable that a sharp line is not formed between the contracted or cooled part and the expanding or heated part, but the tool should be moved in the water in such a manner that an irregular or wavy line is formed, and thus, as it were, intermingle and bring into friendly contact the two opposing forces.

Another and most prolific source of failures arises from the general practice of hardening a tool immediately after it is forged. This is a great mistake. *A distinct heat should always be taken for hardening*, that is to say, when a tool is forged (and this should be done in as few heats as possible) it should be laid aside until quite cold, or, better still, it should be reheated to a blood red, and then placed in lime, dry ashes, sand, or any fine and dry material that will shut out the atmosphere.

The reasons for this are obvious. Take, for example, steel of a suitable temper for turning tools. This in the ingot is high in carbon, or naturally hard, and from its original size—2½ in. to 3 in. square—is drawn down to, perhaps, 1 in. or 1¼ in. square. The hammering which it must necessarily undergo in this operation has the effect of making it more dense and close in the grain, or, in other words, it has become hardened to a certain extent, especially if the hammering was continued until the bar was nearly cold, so as to give the skin a clean and polished appearance. This steel is sent out by the manufacturer; and the workman into whose hands it may come requires, perhaps, a tool of a particular shape or section, which necessitates a great deal of forging and hammering. Again this naturally hard steel is hardened, and if, while in this twice hardened state, and under a very considerable degree of tension, it is still further contracted by being plunged into water, the chances are that it will fly in pieces, especially if it has not a good "body," or there is phosphorus in it. There need be no wonder felt when this result takes place, even with steel of the highest quality; the surprise should be experienced when a sound tool is obtained. The cause is easily understood. Owing to the great amount of hammering, such a high degree of tension is put upon the steel that it is unable to withstand the much greater additional strain caused by the water, combined with the expanding force arising from the imprisoned heat. Sometimes small cracks or "freckles" will appear in the skin after hardening, especially if the article has been subjected to very much forging, and is of a thin double-bevel or convex section. This result is from practically the same cause.

If it is attempted to force on the hand a glove which is too small, it will stretch and give to its fullest capacity, and having gone thus far it will crack and burst; so it is with steel—it also will crack, unless means are adopted to relieve the tension placed upon it after it has been forged and previous to its being hardened.

It must not be supposed that the mere heating of steel removes the effect caused by hammering. I know of no method by which this can be effectually accomplished other than that I have just mentioned, which has the effect of loosening the skin and equalizing the temper, or, to use a common phrase, it is annealed. This done, the hardening may then be proceeded with, and if due and proper care be exercised, and the steel is what it ought to be, the risk of a crack is reduced almost to *nil*, because there is first a regularity and reduction of tension a regularity of temper, a regularity of heat or expansion, and consequently a regularity of contraction; and where these are combined, and in harmony with each other, as they should and must be, little fear need be entertained of failure.

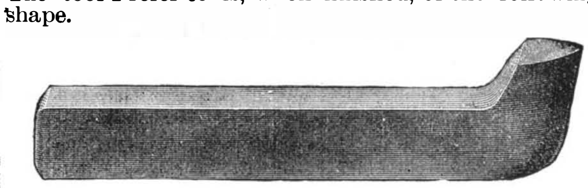
A few words as to the fuel employed in working steel.

I have noticed in some large works that gas coke is used throughout the smithy, possibly with a view to reducing the working expenses. At other works "breeze" is employed, that is, partly calcined cinders from the boiler stokehole, which are picked over and washed. At other works slack or small coal is the fuel employed. *None of these fuels is suitable for tool steel.* The fuel employed in heating steel should be entirely free from all those impurities which it is well known are so detrimental to the production of a pure and high class quality. It has long since been proved beyond dispute that steel when frequently exposed to the atmosphere while in a heated condition absorbs oxygen. Is it not reasonable, then, to infer that it will also imbibe those impure matters which are contained in the fuel by which it is heated?

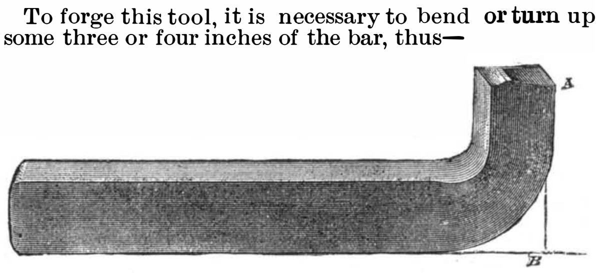
I think steel assimilates very much certain human characteristics in its proneness to evil rather than good. Its parents are (or should be) pure and undefiled, without any sign or symptom of corrupt qualities; it is born, matured, and reared in an unpolluted atmosphere, its surroundings all inculcating and impressing those peculiar features which are to form its position, rank, and character; and yet, with all this care and admonition, the first time an opportunity presents itself for taking in any of those bad qualities which in its training and bringing up were so studiously avoided, then the frailty comes in, and the apple is eaten.

In theory I am much opposed to the use of gas coke, even for heating iron, on account principally of the considerable amount of sulphur it contains, which I think must have a deleterious effect upon the iron. This, however, is somewhat beyond the scope of my paper, and I simply throw out the hint to our scientific friends. That it has an effect upon steel which, to say the least, does not improve its quality, I am quite sure, and strongly advocate a discontinuance of its use. It may be thought that I am suggesting an expensive item in working costs when I advise the use of charcoal for heating steel; but such is not the case, for this fuel will last much longer than is generally supposed, there is far less risk of overheating or burning steel, and what is still more important than all, the charcoal has an affinity for the steel, because, being carbon, it is much more likely to add than to take from the steel that vital constituent absolutely necessary to its composition; and of which charcoal is the most pure representative.

There are two kinds of tools in general use which are particularly subject to failures, not, as a rule, through the quality of the steel, but from the manner in which it is treated. I refer to a particular pattern of lathe tool, and boiler or rivet snaps. The former is very popular in some large works, and is no doubt a handy tool when a sound one is obtained; but it requires a great amount of forging, is a most costly one to the principal, and of frequent annoyance to the manufacturer of steel, because he receives complaints, and has his steel rejected as being of inferior quality when such is not the case. The tool I refer to is, when finished, of the following shape.



To forge this tool, it is necessary to bend or turn up some three or four inches of the bar, thus—



And in order to give the tool, when finished, a firm and level bearing on the rest of the lathe, it is necessary to "upset" or "jump" the steel at A, so as to bring it parallel to and in a line with the shank of the tool, B, and then to pare off so much of the steel as is necessary to give the required shape. I have a very strong objection to this tool, and the following remarks will illustrate the cause and nature of my opposition to its use. Makers of tool steel, whether of a high, medium, or low quality, all prefer to have their steel drawn under the old fashioned tail or tilt hammer. The reason for this is that a blow of equal weight is given on all parts of the bar, and instead of a vertical or crushing blow, as given by a steam hammer, it is, so to speak, a pulling blow, which has the effect of giving an equally distributed tension or contraction from the hammering, and is best calculated to arrange and combine in proper form the minute particles of which steel is formed.

If all this care and trouble be necessary in order to produce a regularity in structural form, it must be at once evident that to disarrange and destroy that organization is, to say the least, injudicious. But this is precisely what is done in forging the tool I have described; and so long as this pattern is in use, failures will continue and steel will be unjustly condemned, for the higher its quality the more numerous will be the disappointments.

With a boiler or rivet snap, the principal source of danger lies in the hardening. Steel for this purpose is of a mild temper, and as but little work is done in the way of forging, I need make no remarks on that process, as a smith must be wantonly careless if he overheats this temper of steel. In hardening, it frequently occurs that the cutting part of the tool will either fly off in pieces or in the shape of a ring, and of course the steel is at once condemned as being of inferior quality. But such is not necessarily the case. The cause of the cracking lies in the fact that between the oblique and cup parts of the tool the substance is so much less than in the body or shank, the contraction in hardening is much greater in that its weakest part, and a sharp line being formed between the cooled and heated parts, the imprisoned heat in its efforts to escape simply pushes off the weaker parts of itself; in other words, those two great enemies expansion and contraction are made to do battle; and as in our social and political economy the weakest goes to the wall, so in steel does the strongest force assert its superiority and without ceremony release itself from its objectionable foe.

The remedy for this failure is very simple, so simple indeed that in many important works it has not been thought of, although based upon a plain and well-known natural law, which is, that heat ascends. If, then, instead of dipping the tool in the usual manner, it is held in a vertical position under a tap, the cup part upward, the difficulty is at once met, for the reason that the heat which is in the body of the tool will ascend and support the weaker part, and instead of a sharp line being formed, the two enemies will become friends and, to quote a phrase sometimes used, "live happily together ever afterward."

The hardening of rolls frequently proves a most vexatious and expensive operation, owing to the many failures which take place. It is an indispensable condition that rolls, when finished, should be extremely hard, and in order to accomplish this it is necessary that a steel high in carbon should be used. There is, I think, more care required in the hardening of rolls than any other tool. In the first place, the forging must be very carefully performed, and a thorough annealing given before any attempt is made at hardening. A very careful and experienced workman is necessary, who should perfectly understand the temper of the steel, so as to be guided as to the maximum of heat that may with safety be given, and every precaution taken that the heat has penetrated quite to the center of the roll. When plunged in water or whatever hardening liquid is employed, the edges become cooled or contracted much sooner than the interior, and have consequently far less resistance to the expansion caused by the imprisoned heat than the other parts of the roll. If it is removed from the water before it has become quite cold, the edges will in all probability fly off, or it will burst in the center.

This may be explained by the fact that the atmosphere has less resistance to the confined heat than water, and being as it were on the alert to escape, will avail itself of the most ready and convenient way to do so.

My advice to makers of cast steel rolls is to select a steel of *good "body" and suitable temper*, and no complaint should be made if a high price is charged for it. After having forged the roll with as few heats as possible, thoroughly annealed it, and after having turned and prepared it ready for hardening, have a suitably constructed furnace or hearth, with charcoal for fuel; be careful to obtain a thorough but gradual heat, let your hardening liquid be just chilled and not too small in quantity, into which plunge your roll vertically and let it remain until quite cold. If all these precautions are taken, success should certainly crown your efforts; but bear in mind that your whole and sole attention must be given to the operation, for the slightest carelessness or the least inattention may lead to a disastrous result, and both time and money will be wasted.

Taking into consideration the unavoidable laws of expansion and contraction, and the results that must inevitably follow inattention to them, we see how necessary it is that none but skilled workmen should be allowed to manipulate steel.

The art of hardening, tempering, and the general treatment of steel, is one that cannot be acquired with a little practice; it requires long and varied experience and an amount of intelligence that unfortunately is not common.

It is a most regretful fact, both for manufacturers and consumers, that, with many workmen, steel is steel; that is to say, the same treatment which is given to steel of low price and quality is also given to that of high quality. Nor can I exonerate principals even from this imputation. It can be very easily understood that great pressure is brought to bear by the representatives of manufacturers in order to effect sales. This, so far, is perfectly fair and legitimate, and no reasonable objection can be made to such procedure; but it is when so-called "best tool steel" is offered at absurd prices that the purchaser should know whether or not it is possible to produce such a quality for the price at which it is offered to him. If consumers would only study their own interests, and acquire simply a rudimentary knowledge of the art of manufacturing best tool steel and the cost that must be incurred in its production, they would save themselves much loss and annoyance, and the pettifogging firms who are vending such worthless rubbish would soon receive their quietus. Nothing in a workshop is so dear as cheap tools. When steel is worked into tools by the consumer, it frequently occurs that the first cost does not represent one-twentieth part of the cost of the finished tool. Take for example a die, upon which frequently weeks of the most costly workmanship is expended, and if, when in hardening, a flaw develops or a water crack appears, there is an absolute and total loss. Or take again a lathe tool made of common steel—the first cost is comparatively nothing when put side by side with the expenses incurred by its use. There is to be considered the number of times it requires to be ground, that when grinding the tool the lathe is standing, the workman's time employed in a profitless operation, power being wasted; and frequently in addition to those expenses may be added that of the smith and fuel in "doing up" the tool.

It is the tendency of the present age, and especially the rule with some large consumers, to purchase in what they suppose is the cheapest market because the prices solicited are the lowest. This is a very practical illustration of the old adage, "penny wise and pound foolish;" and if such purchasers would only investigate the matter, they would find a reduction in first cost concur with a considerable increase in their labor account or working expenses.

It has been stated at a meeting of this institute, and I believe with perfect accuracy, that iron suitable for the manufacture or production of an economical quality of steel has averaged in price during the last forty years the sum of £25 a ton; taking this as a basis, I assert without fear of contradiction that a good and useful quality of steel cannot be sold, under ordinary circumstances, at a less price than from £56 to £70 a ton.

In this age of discovery and invention, it would be bold on my part did I claim that no other method of making high class steel than those which have for so

long been in use in this and other countries will ever be found out. I am, however, on the safe side when I say the old methods are still to the front, and although we are constantly hearing and reading of some "wonderful discovery" by which the price of tool steel will be reduced to less than one-half its present price, that is about the limit of our knowledge and information. There appears to be a kind of epidemic among these brilliant inventions, for no sooner is their birth announced in all the flaming coruscations of a whole page advertisement than the fatal disease comes upon them, their fragile constitution sinks, and they are buried.

My advice to consumers is to be very wary and cautious when cheap—that is, low-priced—steel is offered them, for they may rest fully satisfied it is not made from that material, nor by one of those old processes which is absolutely necessary, or, if it is really good steel, then some ulterior object is the inducement. It may be, as the old adage says, "a sprat to catch a whale."

I come to another phase in the working and treatment of steel. We have noticed the results which follow the not giving a gradual and thorough heat, and perhaps these precautions form the greatest obstacles and principal sources of failures.

Now, permit me to direct your attention to the effects resulting from taking or employing a too high degree of heat. This, by the bye, is, I think, a most interesting subject for scientific investigation, and I am not, perhaps, committing a breach of confidence when I say that most probably we may in a short time have some important particulars given us by two learned professors, who are giving this subject their investigation.

By the term "overheating" I do not wish to convey the idea that it is necessary to heat steel to a white or welding heat. It is quite sufficient if it is heated beyond the point its nature or temper permits. For example, if turning tool steel is heated to any point beyond cherry red (that is, the highest red heat immediately preceding the yellow heat), it is spoiled; but if, for forging purposes, a low temper of cast steel is heated to a "wash" or welding heat, no particular damage is done, because the work that is usually put upon such steel, together with the comparatively low heat employed for hardening, restores very nearly its original properties.

To those who are familiar with the steel trade it is a fully recognized fact that a far higher degree of heat is necessary to melt a mild or soft steel than one which is of a high temper. What, then, must be the inference? Common sense will at once point out that if a comparatively low degree of heat will melt steel high in carbon, only a low degree of heat should be employed in working it.

When steel has been overheated, the fracture has a very coarse and crystallized appearance. It does not, however, necessarily follow that any particular chemical change has taken place, nor that the steel is entirely spoiled. The appearance I have indicated arises in my opinion entirely from a mechanical change.

I draw a very distinct line between overheated and burnt steel. The fracture in each case is, to the unpracticed eye, much the same, but the change that has taken place is widely different in each case.

When steel has been burnt its nature has gone, its vital powers, so to speak, have been destroyed, and no means exist, so far as my knowledge extends, of bringing back or restoring those properties. This I call a chemical change. If steel has been only overheated, just sufficient to disarrange and enlarge its molecules, then there are means for reducing and rearranging those particles. This change I designate as mechanical.

There is another manner in which steel is spoiled other than by overheating or insufficient heating, and that is by too frequent heating.

Tools upon which a great number of heats are taken can never do the same amount of work as those which have been less exposed to the fire. The reason for this is that at each heat the original nature of the steel is weakened and reduced, and the repeated exposure to the atmosphere while in a hot and soft state permits the absorption of oxygen. A workman may be very careful not to exceed the proper degree of heat, and yet, from the cause above named, not be able to produce a satisfactory tool,

In the case of too frequently heated steel, the fracture is much the same in appearance as with overheated or burnt steel, but the change is twofold, namely, chemical and mechanical.

With this, as with burnt steel, I believe there are no known means of restoring the properties which have been removed, but there are several methods for bringing back or restoring to very nearly its original condition steel which has been overheated.

As the degree of deterioration must be variable, so must the means adopted for bringing back the original properties be attended with results approximate to the damage done.

Steel that has been only overheated may, to an extent, be restored by reforging and rehardening at the proper heats, but it will never fully recover its previous qualities by this or any other method.

Another and perhaps more convenient method is to heat the steel to about cherry red, and then plunge it into boiling water, allowing it to remain until quite cold. The effect of this is to produce only a slight contraction, and by repeating the operation the steel will, in many cases, be made to recover its original state; but if after the third time the desired change has not taken place, it may be considered that further attempts will prove futile. The advantage of this method lies in the fact that, as the contraction is reduced to a minimum, the risk of cracking entirely disappears.

There are a variety of fluids and substances which may be used for the purpose of restoring overheated steel, such, for example, as water made thick with soap, mixtures of resin, fat, and oils—indeed, anything of a similar nature which has but slight caloric conductibility.

A very simple and sometimes effective regenerative composition is made of three parts resin and two parts linseed oil, blended by gently simmering, under constant agitation, over a slow fire. These ingredients form a thick brown liquid of about the same consistency as molasses, into which the steel may be plunged at a cherry red heat. It may be necessary to repeat the operation, as with boiling water.

Another mixture is composed of four parts tallow, four parts pitch, three parts sal ammoniac, and one part yellow prussiate of potash.

A very complicated composition has come under my notice, made as follows: Five hundred parts tallow, one hundred and twenty-five parts black pitch, three hundred and seventy-five parts sal ammoniac, one hundred and twenty-five parts yellow prussiate of potash, seventy-five parts black pepper, thirty parts common soap, and thirty parts common salt.

These are a few of the nostrums used for the purpose of restoring overheated steel. I attach, however, no importance to them as to their chemical value, which I believe is *nil*. The success attending their use lies in the fact that each mixture is but an indifferent conductor of heat.

The change effected is simply a mechanical one. The minute particles of which steel is composed having become enlarged, disarranged, and crystallized by overheating, are transformed by slow contraction to nearly their original size and position.

There are also a great variety of mixtures used for the purpose of hardening, some of which have undoubtedly a greater power of contraction than water pure and simple. But if a sufficient degree of hardness cannot be obtained by using old water, it is seldom any of the mixtures will give the desired effect. I should state that by old water I mean the water that is used by the smith for ordinary quenching purposes, but care must be taken that no saponaceous matter is contained in the water.

It is impossible to prescribe such an application or remedy as would have a universal effect. Much must depend upon the intelligence of the workman. The principle, however, remains the same in every case.

If steel has been overheated in the forging, that is, in being drawn from the ingot to the bar, the best remedy is the first named, that is, reforging to a smaller size. If the overheating has been done by the smith, one of the other remedies may be tried; but for denaturalized steel I know of no remedy but recarbonizing. Burnt steel should be thrown on the scrap heap, as nothing, I believe, can be done to make it of the slightest practical value.

There are individuals going about the country who profess to have some wonderful secrets as to the restoration of burnt steel. Such persons are mere quacks, whose existence depends upon the credulity of their victims. Frequent trials have proved most conclusively that these individuals can only change or restore overheated steel, but with burnt steel they are entirely at fault.

These are a few of the most important points to be observed in the treatment of steel.

Of course much depends upon the quality or "body" the steel contains. By the term "body," I mean those properties which bear the same relationship to steel that bone, sinews, and fiber bear to the human frame.

Good wine cannot be produced from inferior grapes, nor can good steel be manufactured from unsuitable material. In Sheffield there is an old proverb to the effect that "you cannot put a certain personage in the pot and produce a saint." Whether or not the inventor of this familiar aphorism had in mind at the time of its birth the fact that sulphur and phosphorus are very undesirable elements, I am not in a position to say. However, the adage can better serve the present purpose if we take it as meaning, that if good steel is required, good material must be used in its production, and for good material a high price must be paid and good workmanship be employed; the result will be a good article, for which a fair and reasonable price must be demanded.

I hope these simple facts will make such an impression on the minds of all those who are in any way connected with the steel trade as will bring about a considerable change. Unfair and dishonest trading may and does render it difficult for manufacturers of the legitimate article to hold their own in the markets of the world, but the high and honest quality must assert itself and eventually triumph; and even as a cork will sink when drawn into the vortex of a whirlpool, so will unfair and unprincipled traders create such a whirlpool of competition that ultimately they will be drawn into its vortex and deservedly sink into commercial oblivion.

There is, however, I am much pleased to say, a gradual but sure awakening to the fact that the best article is the cheapest; and especially is this applicable to large private firms, many of whom were at one time purchasing tool steel at very low prices, but are now paying more than double, and in some cases more than treble, the prices originally paid. I have no doubt the change would be far more rapid than it is were it not for the prejudice (arising sometimes from lack of knowledge) which exists. I cannot, however, entirely blame workmen for this. They have become accustomed to steel of such inferior quality, which permits almost any kind of rough treatment, that when steel of a good quality, requiring more careful treatment, is placed in their hands, they either do not know or forgot how to treat it. It is the masters' fault and the masters' loss.

It is very difficult to meet the opinions and beliefs of workmen with regard to steel. A most amusing case came under my notice some little time since.

A firm employing a large number of men who are paid by results, or piece work, had for some time used a certain brand of steel, which I will call number one. The principal, who is thoroughly practical, had another steel introduced to his notice, and which, after a series of trials, he decided to adopt. I will call this steel number two. After number two had been in use for some months the workmen discovered that another steel than that which they had been accustomed to use was being supplied to them, and at once decided it was perfect rubbish, and if it were intended to use that kind of steel, a higher rate of remuneration for their work must be paid. This decision on the part of the men was laid before the principal, who after some little discussion promised that an alteration should be made. The men were quite confident of having gained their point, and the principal was true to his promise. An alteration was made, but it was only in the shop marks by which the two steels had hitherto been distinguished. No. 2 received the same mark as No. 1, a small additional mark being added which was only known to the principal and the smith, and for the purpose of knowing one steel from the other. This occurred now more than two years since, and although No. 2 is in general use no complaint has been made, and the men believe they are still using No. 1.

I mention this case out of many others in order to show how necessary it is that principals should possess a knowledge of steel, and not only possess it but exercise it, so that they may decide what is best for their own interests, and be able to select such workmen as will devote their energies and intelligence to the promotion of that system of careful and economical working which must form the basis of a prosperous concern.

It would prove a great boon to the rising generation if in our technical schools the proper treatment of steel could be practically taught. It is true students are shown how to harden a chisel or simple lathe tool, but that is not sufficient; a much greater variety is necessary. An objection may be raised that high-class steel is too expensive to experiment with, but surely there are manufacturers who would be sufficiently generous to admit to their works a class of students when any operation of an instructive nature was to be performed.

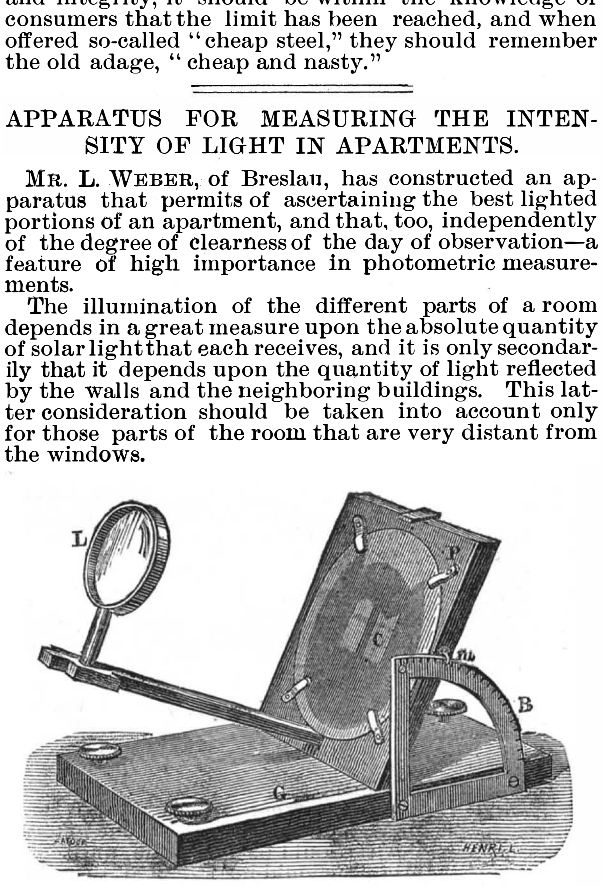
In conclusion, permit me to again plead the cause of high-class steel.

It is the duty of all who study, not only their own immediate interests, but the welfare and prestige of our country, to discourage the nefarious system of reducing prices below that point at which it is possible to produce an honest article. Competition, when healthy, sound, and upright, is good for any country, whether it is of local or foreign origin, and while it remains a question of quality, no real cause of complaint exists; but when that competition has reached a point at which it is impossible to maintain commercial uprightness and integrity, it should be within the knowledge of consumers that the limit has been reached, and when offered so-called "cheap steel," they should remember the old adage, "cheap and nasty."

APPARATUS FOR MEASURING THE INTENSITY OF LIGHT IN APARTMENTS.

MR. L. WEBER, of Breslau, has constructed an apparatus that permits of ascertaining the best lighted portions of an apartment, and that, too, independently of the degree of clearness of the day of observation—a feature of high importance in photometric measurements.

The illumination of the different parts of a room depends in a great measure upon the absolute quantity of solar light that each receives, and it is only secondarily that it depends upon the quantity of light reflected by the walls and the neighboring buildings. This latter consideration should be taken into account only for those parts of the room that are very distant from the windows.



APPARATUS FOR MEASURING THE INTENSITY OF LIGHT IN APARTMENTS.

In the case under consideration, Lambert's law, then, must be formulated thus:

$$h = H \mu \omega \sin \alpha.$$

The degree of light, h, sought is, on a horizontal surface, proportional to the brilliancy, H, of the illuminating sky, to the albedo (reflecting power), μ, of the illuminated surfaces, to the polygon, ω, which represents the surface of the sky visible from the illuminated surface, and finally to the angle, α, of incidence of the luminous rays upon the surface considered.

Out of these four quantities, we may regard the brilliancy, H, and the albedo, μ, as constants for the different points of observation; there remains, then, only the product $\omega \sin \alpha$, which expresses the degree of illumination of a place. The polygon, ω, is obtained as follows: Let one figure to himself, from some point of the illuminated surface, rays that are tangent to the neighboring roofs, etc. Such rays will limit that part of the sky that one perceives from this point, and will give a polygonal surface that gives the polygon, ω. This latter is then measured in square degrees, a unit obtained by constructing a square of one degree upon the surface of the sphere. This total surface, then, comprises 41,253 square degrees. For a sphere 114·6 mm in diameter, we represent 1 square degree by an area 2 mm. square; then 1 square degree will be equal to 4 square millimeters.

The apparatus shown in the figure permits of measuring both the square degrees and the angle of incidence, α. The base, G, is made horizontal, by means of leveling screws and a lead wire, at the place to be studied, and then the part, P, is so inclined that the datum point, m, shall correspond to the zero of the graduation of the sector, B. In this way the lens, L, will project a luminous point of the horizon exactly upon the point, C, placed in the center of P. At a distance of 114·6 mm. the lens gives an image of maximum intensity. The block, P, is covered with pattern paper with 2 mm. rulings, which is fixed partly by the point, c, and partly by springs; then the lens, being turned toward the window, gives upon the paper a polygonal and irregular image of that part of the sky that is seen through the window. The cartoons of this polygon are traced upon the paper, the number of squares and fractions embraced are counted, and in this way the surface, ω, which expresses in square degrees the visible portion of the sky, is accurately obtained.

To measure the angle, α, it would be necessary, strictly speaking, to make a separate observation for each portion of the visible surface of the sky, by causing

the images to fall exactly at *c*; but we may be simply content with a mean angle of incidence, and this is obtained by inclining the block, P, until the point, *c*, occupies the center of the image of the portion of the sky observed. The mark, *m*, then gives the indication of the angle, α. The product $\omega \sin \alpha$ may be considered as the reduced surface, and gives a quantity that may be taken as a measurement of the illumination of the place of observation, exclusively, however, of the light reflected by the walls.

According to numerous observations made in schools, the illumination, in order to be sufficient, should be expressed by at least fifty square degrees.—*La Lumiere Electrique.*

HISTORY OF THE VELOCIPEDE.

IT would be difficult to say who was the inventor of the velocipede—a vehicle which has now become practical, and the uses of which are multiplying from day to day. We cannot fix the origin of it, but may recall the fact that we have described in these pages the curious mechanical carriage that Ozanam, a member of the Academy, described in 1693. This four-wheeled vehicle was set in motion by means of two pedals, was operated at Paris for several years, and appears to have been devised by one Richard, a physician at La Rochelle. Since that epoch, a large number of inventors have often tried to construct mechanical carriages, and we may especially cite the tentatives made by Blanchard, the aeronaut, about the year 1780, a short time before he formed the project of a flying ship.

At the beginning of this century, a very ingenious style of velocipede was devised, which consisted of two wheels mounted in the same plane, and supporting a saddle, of which the rider sat astride, with his feet touching the earth. This bicycle was pushed along by means of the feet. This system appears to have been devised by Nicephore Niepce, one of the inventors of photography. The apparatus, which was very popular in Paris after 1815, and especially in 1818, was made entirely of wood. We have recently had the good fortune to receive a remarkable collection of old engravings, that will allow us to complete the little-known history of this first bicycle, and to follow its progress in England, where it found great favor. These engravings, of which we reproduce a few specimens herewith, are dated, and accompanied with very complete descriptive titles that are very valuable to the historian.

The first wooden bicycle was improved at London, at the end of the year 1818, by making of it a light apparatus, constructed of metal, as shown in Fig. 1. This figure is a reduced fac-simile of the original English print, which is dated 1819, and is entitled "The Pedestrian Hobby Horse." The apparatus was based upon the same principle as the wooden bicycle used at Paris. It consisted of two very light metallic wheels, situated in the same plane. The fore wheel revolved on a vertical axis, and was made to pivot to the right or left by means of a lever. The rider sat astride of a saddle between the wheels, with his feet touching the ground, as before.

At the same epoch, velocipedes were made for the use of women (Fig. 2). In these the saddle was mounted upon a U-shaped frame, so that the gown remained a few fractions of an inch above the ground, without there being any necessity of lifting it. The saddle was fixed at the extremity of one of the branches of the U. The principle of the apparatus was the same as that of the other.

Another engraving, that it is hardly necessary to reproduce, shows the interior of a special riding school for velocipedists. This school, which was organized by a man named Johnson, was at No. 40 Brewer Street, Golden Square. The print shows that there were then, as there are now, skillful bicyclists. Some of these are seen skimming over the floor of the school, with their feet placed upon the hub of the front wheel.

Although the first bicycle had a large run at Paris, it had no less a one at London, as is proved by a remarkable caricature by the celebrated Cruikshank. This curious print, which we reproduce herewith, considerably reduced, is dated July, 1819, and is entitled "Every man on his perch, or going to Hobby Fair." Here is seen an amusing procession of all the trades and professions upon the pedestrian velocipede, from the preacher to the boxer and fish peddler.

Along with this caricature, we find a series of others, all dated 1819. They well show that this year was the one in which the bicycle was the rage at London. Fig. 4 represents a fancy velocipede, in which a gentleman, accompanied by his groom, is giving a lady an airing. Fig. 5 is much more interesting, for it shows us a well constructed tricycle actuated by pedals. The lady who is maneuvering it sits high and dry upon a seat placed between two wheels, and is actuating the latter by means of two long pedals, forming a lever. The front wheel pivots around an axis and serves for steering the apparatus. This print, which marks the advent of a new improvement, is dated May 22, 1819. It is entitled "The Ladies' Hobby."

FIG. 1.—THE VELOCIPEDE IN 1819.

FIG. 2.—VELOCIPEDES FOR LADIES IN 1819.

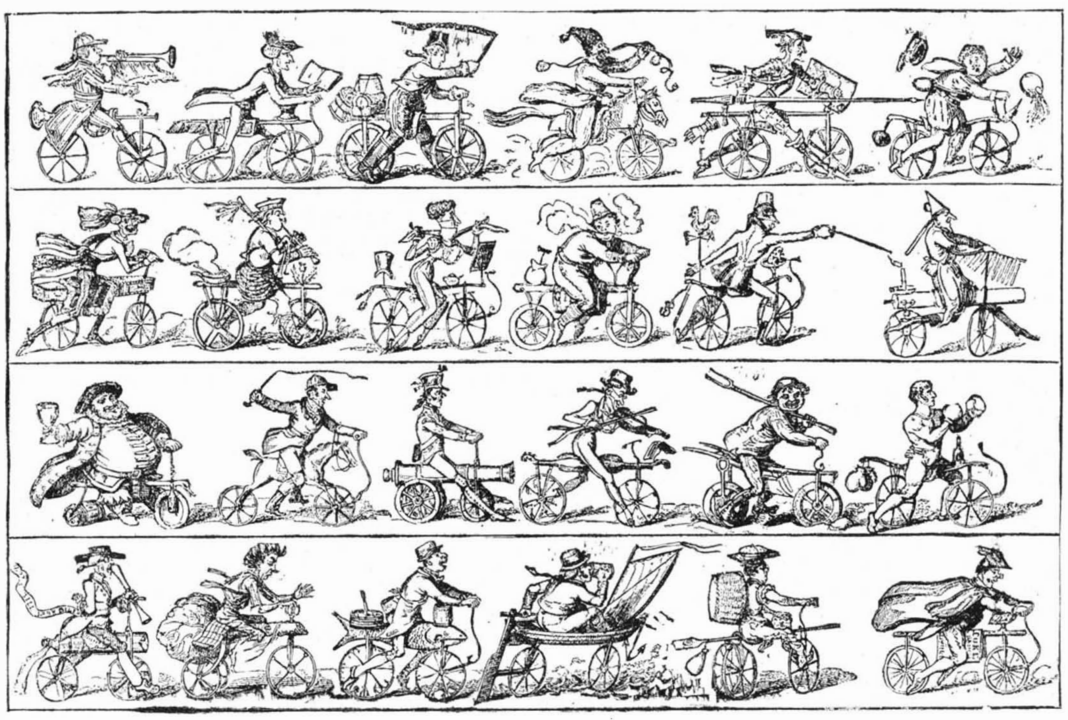


FIG. 3.—A CARICATURE BY CRUIKSHANK.

FIG. 4.—FAMILY VELOCIPEDE.

FIG. 5.—A TRICYCLE OF 1819.

After this wonderful popularity at Paris and London, the velocipede for a long time remained in obscurity, and it is only within twenty years that a few ingenious manufacturers have taken it up again and transformed it into our present remarkable apparatus.—*La Nature.*

[CONTINUED FROM SUPPLEMENT, No. 577, page 9212.]

OUR BUILDING STONE SUPPLY.

By GEORGE P. MERRILL.

OF limestones other than marbles, stones used only for general building, but which, owing to color and lack of polish, are unsuitable for decorative work, we have time and space to notice only the fine grained, light colored varieties of Indiana, Illinois, and Kentucky. These are often oolitic in texture, and vary from almost white through dull cream color to drab. The evenness of the grain of these stones, their softness, and at the same time toughness, render them adapted, in a remarkable degree, to general building and highly carved work, especially for country residences, and in cities where there is but little smoke or gaseous exhalations from manufactories. For work of this kind there is no stone, native or foreign, with which they can compare, though they bear a very close relationship to the Bath (England) oolite, which has been in use since early in the thirteenth century. The American oolites are, however, harder and less absorptive, the latter item being one of importance in a climate so trying as that of the United States.

The quarrying of sandstone, or *freestone*, as it is so often called, appears to have begun with the itinerant working of the extensive beds of Triassic brownstone in the vicinity of Portland, Connecticut. It is stated that the first quarry here was opened "where the stone originally rose high and hung shelving over the river." The value of the material was early recognized, and it began to be utilized for building and for monuments soon after the settlement of Middletown, on the opposite bank of the stream. The quarries were at this time regarded as common property, and were worked as occasion demanded, both by the people in the immediate vicinity and by those living at a distance, who carried off the material in scows, boats, and vehicles of various sorts, nor thought of giving anything as an equivalent. This system of free quarrying had assumed such proportions as early as 1665, that on September 4 of that year the citizens of Middletown assembled and voted that "whoever shall dig or raise stone at ye rocks on the east side of the river (now Portland) for any without the town, the said digger shall be none but an inhabitant of Middletown, and shall be responsible to ye town twelve pence pr. tunn for every tunn of stones that he or they shall dig for any person whosoever without the towne; this money to be paid in wheat and pease to ye townsmen or their assigns for ye use of ye towne, within six months after the transportation of said stone."

How soon the surface rock was exhausted, and it became necessary, as now, to go below the level of the ground for suitable material, we are not informed, but the quarry thus opened was at length disposed of by the town, and has passed through various hands, among whom the names of Shaler and Hall have ever been conspicuous.

The present industry is comprised in three large quarries, extending from a point near the ferry northward along the river for some three-fourths of a mile. These vary from 50 to 150 feet in depth, and their total yield of stone of all grades, during the time of their operation, has been roughly estimated at 4,300,000 cubic feet. The rate of progress has been given as follows: In 1850, the number of men employed at the three quarries was 900, with 100 yoke of oxen, 30 vessels being regularly employed to convey the quarried material to market, each vessel carrying from 75 to 150 tons and making from 20 to 30 trips each season. Two years later, the number of men regularly employed had increased to 1,200, while 200 more were engaged

on contract work. The stone, even at this date, had found its way to markets as far west as Milwaukee and San Francisco. The census returns for 1880 showed the total number of hands employed to be but 925, with 80 yoke of oxen and 55 horses and mules. The falling off in numbers may be considered due to the introduction of machinery and improved methods of working. The total product of the three quarries for this year was about 781,600 cubic feet, valued at not less than $650,000. A fleet of 25 vessels of various kinds was regularly employed in conveying this material to market. In their present condition, the approaches to these quarries are more interesting than beautiful. The entire landscape is of a brownish color, and an ankle-deep fine, penetrating dust is everywhere prevalent.

The ground is strewn with huge blocks of stone, about and among which swarm the busy workmen and the ever-present small boy and omnivorous goat. The beds of stone lie nearly horizontal; and in quarrying, a natural point face is often selected as the quarry wall, which is followed down to any practicable depth, leaving thus an absolutely perpendicular wall on three sides, from 100 to 150 feet in height. The fourth side is usually less abrupt, allowing passageway for teams and workmen. In getting out stone, large masses of several hundred tons weight are first loosened from their bed by means of blasting, the drill holes being sometimes twenty feet in depth, ten inches in diameter, and charged with from twenty-five to seventy-five pounds of powder. These large blocks are then broken up by cutting, with picks, long grooves, into which iron wedges are inserted at intervals of a few inches from one another. Workmen armed with heavy hammers then pass along this line, dealing telling blows upon the wedges, until the stone yields to the strain, and falls apart. The blocks are then attached to a steam windlass and drawn to the surface. In getting out the finer class of material, channeling machines are used to some extent, as in quarrying marble. Once out of the quarry, the blocks are attacked by workmen armed with what are simply ordinary pickaxes with short straight points, who trim off all superfluous and waste material. The blocks are then slung, by means of chains, under the axles of exceedingly awkward and overgrown looking pairs of wheels and drawn by oxen to the river's bank, where they are loaded upon vessels. Very little of the stone is dressed at the quarries, nearly all being shipped in the rough to New York and other large cities, where it is worked up as occasion demands. It is found in all our leading markets, and several cargoes have even been shipped to San Francisco *via* Cape Horn.

The quarries are actively worked only from May to November, and this not because the inclemency of a New England winter is too much for the quarriers, but rather on account of the stone itself, which is much more seriously affected by extremes of temperature. All stones, and sandstones especially, contain, when freshly broken from the quarry bed, varying amounts of moisture, or quarry water, as it is technically called. If exposed to freezing while in this condition, they are, if not actually burst and ruined, at least rendered less tenacious. In many localities it is necessary to flood the quarries with water, or cover them with earth, on the approach of cold weather, to prevent serious damage from this cause.

But the Connecticut brownstone is not of interest from an economic standpoint only. To the geologist and all lovers of nature, it has furnished many an hour of honest study and pleasing recreation. The lithologist will tell us that this entire formation of hundreds of feet in thickness, extending from Long Island Sound to northern Massachusetts, and having an average width of twenty miles, is entirely made up of fragments of granite or gneiss; that under his microscope the water-worn particles of quartz, feldspar, and mica are still readily distinguishable. And indeed we may accept it as a foregone conclusion that this whole formation is but an indurated sandbank. Proof positive of this would seem to be furnished by the ripple and wave marks which are even now found separating the various layers of stone, just such marks as are today being formed upon our modern sea beaches and river banks; and also by the fact that in quarrying it is not uncommon to uncover the tracks of some huge bird or reptile, who, wading in shallow water to gain his daily meal, left the imprint of his three-toed feet in the soft mud, to slowly petrify and be again brought to light after thousands of years have elapsed.

But all our sandstones are not brownstones, and neither is the entire supply brought from Connecticut. Massachusetts, New Jersey, Pennsylvania, and Maryland also furnish large quantities of this material, while the deep blue gray "bluestones" or flagstones of New York and Pennsylvania, and the "Euclid bluestones" and "Berea grits" of Ohio, are almost too well known to require especial notice. The first mentioned of these are found in New York State, in a comparatively narrow belt west of the Hudson River, mainly in Albany, Greene, and Ulster Counties, and belongs geologically in great part to the Hamilton group of the Devonian formations.

In the ledge the stone occurs in layers varying from a few inches to three or four feet in thickness, and which adhere to one another with such slight tenacity as to readily separate by bars and wedges, without the use of explosives. The quarries are mostly shallow affairs, and the methods of operating them crude in the extreme. It was from a quarry of this stone, in Sullivan County, that was obtained the monster flagstone, 25 feet long by 15 feet in width, which now forms a portion of the sidewalk in front of the Vanderbilt residence on Fifth Avenue, New York. The size of this stone was, however, limited in this, as in many other instances, only by the means of transportation, neither railroad bridges nor canal locks allowing passage for blocks of larger dimensions. But one of the most important sandstones at the present day is that known as the Berea grit, or more popularly perhaps the Ohio freestone of Ohio.

This stone, which belongs geologically to the subcarboniferous formations, and which differs from the Triassic brownstone in having had all its ferruginous coloring matter leached out of it by the prevailing organic matter of the coal age, occurs in beds from 10 to 75 feet in thickness and occupying a belt of country extending from the southeastern corner of Ashtabula County westward into Erie County, and then southward to the Ohio River. In quantity, it is needless to say, it is inexhaustible. In color, it is light, almost buff, of fine and even texture, and soft enough to work readily and evenly in any direction. It is by far the most common sandstone now in use, both for general building and for trimming purposes, in the United States.

Its chief defects are pyrite (sulphide of iron) specks, which rust and stain the stone, and its liability in finely carved work to succumb to the crumbling effects of frost. I cannot leave this subject without calling attention to the wonderful evenness of the bedding of the stone as displayed in the quarries and as described by Prof. Orton. In some of the quarries in Trumbull County, it is stated that blocks of the stone ten feet square and only one and a half inches thick have been extracted, and with surfaces so smooth and even that a straight edge laid upon them would touch at every point.

In one case, a strip one hundred and fifty feet long, five feet wide, and three inches thick, was reported as raised from the quarry bed, and the various layers of the stone, though closely compacted, are perfectly distinct, and adhere to one another, "scarcely more than sawn planks in a pile." Truly, had the stone been laid down for the express purpose of being quarried, the conditions could scarcely have been more favorable. As an illustration of the extent to which the stone is utilized, it may be stated that in the town of Berea alone, nearly forty acres of territory have been quarried over to an average depth of forty feet.

A few words in conclusion regarding the future of the industry. Of materials for all ordinary purposes of construction the supply is inexhaustible. With the increasing wealth and culture of the people, the demand for other substances than wood and brick is certain to increase. In no State are the resources as yet taxed to their utmost, even are they fully known. The fact that Maine and Massachusetts are at present producing two-thirds of all the granitic rock used is not due to lack of equally good material in many other States, but rather to the ready accessibility of the quarry regions by both rail and water routes, and proximity to the leading markets. Virginia, North and South Carolina, and perhaps Georgia, together with some of the more northern and western States, contain granites of equally good quality, but poorer facilities for quarrying, lack of market and means of transportation, together, it is in many cases to be feared, with lack of enterprise, have left the quarries unopened, or if worked at all, only in such a way as to cause them to be overlooked as permanent sources of supply. The two first named States will doubtless continue for many years to furnish, as now, a large share of the granites used in this country. With marbles, limestones, and sandstones, however, the case is quite different, since the quarries of these stones are nearly all situated inland, and are dependent, largely, upon railways for transportation facilities.

With the opening up of lines of railways, then, throughout the South and West, we may expect the quarry products of these regions to enter sharply into competition with those of the more eastern States. North Carolina contains very promising outcrops of both marble and sandstone, but which are now scarcely at all worked, for the reasons just mentioned.

The white, colored, and pink marbles of Georgia are already in the markets of Chicago and Philadelphia, and it will be a question only of quality and adaptability that shall decide whether or no these shall drive the Vermont marbles before them, as those of Massachusetts and Connecticut were, in their time, driven out by those of Vermont.

Beautiful sandstones of warm and mellow tint are to be found in many of the Western States and Territories, which are not now quarried, simply because there is no near demand for the material, and transportation is expensive. Let such local demand arise, as some time must, as shall cause the quarries to be once opened, and there is reason to suppose the stone will be sent out to other States, now supplied from Eastern sources.

The people of the United States have, as yet, much to learn in the way of properly quarrying and utilizing the quarried material. Accustomed to things on a large scale, the quarryman seems scarcely to think of carefully picking and working the choice pieces of small size, however beautiful they may appear. If the material cannot be obtained in blocks or slabs of large dimensions free from flaws, away it goes into the dump and is forgotten. I remember to have seen in the immense piles of refuse about the quarries of Vermont, many beautiful blocks of a blue-black and white breccia marble, which, because it did not yield a perfect surface on sawing and was somewhat flawed, was at once discarded. The same material in any other country would be carefully backed and filled, and if sent to the United States, would find a ready market for wainscotings and interior decorative work.

The same may be said regarding the breccia marbles of Maryland. There is scarcely one of the foreign marbles now imported, excepting the common white and clouded varieties, but requires filling, if indeed it is not so fragile as to require a backing of cheaper material to give it strength; yet we are not content to work our own materials, unless, as is the case with the colored marbles of Tennessee, slabs of almost any required size can be obtained free from all flaws and blemishes.

Our great need at the present time is a richly colored marble for interior decorative work, such as the Siena yellow, the French griotte, or the so-called Numidian marbles from Tunis and Algeria. The supply of the so-called "onyx marble" is also very limited.

The San Luis Obispo rock is scarcely seen in our Eastern markets, the supply being obtained chiefly from Mexico and Egypt. It is possible that search for the latter stone has been carried on neither intelligently nor systematically, and it seems very probable that some of the stalagmitic deposits on the floors of our numerous caves may yet prove of economic value. Blocks and slabs of this stone from the Luray caves, and now on exhibition in the National Museum, are of no mean quality, though pieces of large size cannot be obtained, owing to its extreme brittleness and many flaws. It should be noticed that in most marbles those variously colored veins and streaks which lend beauty to the stone are, in reality, flaws, and weaken, while they otherwise enhance its value.

American taste in only too many instances apparently fails as yet to fully appreciate the incomparable beauty and majesty of a stone structure over one of brick. This must be almost painfully evident to any one who has had occasion to compare the inharmonious piles of red brick and galvanized iron which constitute so large a share of the residences in our capital city with the more elegant and substantial appearing dwellings of Baltimore and other more Eastern cities. Yet Washington has an abundance of excellent stone in the near vicinity, and is within easy communication of all the leading quarry regions of the country.

Great difficulty is often experienced, I am told, in getting new varieties of stone introduced into the markets and into general use. While the fact may be recognized that materials now in use are not in all cases satisfactory, few feel like assuming the responsibility of trying a new variety, or an old variety from a new source—a fact that is doubtless largely due to ignorance of what constitutes a really good stone, or what the latent qualities of any stone, good or bad, may be. This hesitancy on the part of architects or builders to accept a newly discovered and untried material has often added greatly to the cost of building, through the payment of freightage for hundreds and perhaps thousands of miles, when equally good stone could, it may be, have been obtained within one-tenth of that distance, or possibly close at hand. Thus, Quincy granites have been carried into Maine, to be used within three miles of the Hallowell quarries, and the same stone was also used in building the custom house at Savannah, Georgia. A stronger illustration still is offered in the case of the first stone building erected in San Francisco, which is stated to have been of granite brought from China; and even this is scarcely equaled by an occurrence of very recent date, that of the shipment of two cargoes of Portland brownstone to this same city *via* Cape Horn. Such a hesitancy to accept untried materials might seem laudable were those selected in their places in all cases of the first quality. Such, however, is not the case, and the selection in only too many instances seems to be governed by a mere whim or caprice of the party in authority. A point of great importance, and one that does not seem to be fully realized, is, that not all stone from the same quarry, or even from the same stratum, is equally good. This is especially true of sedimentary rocks, the different layers of which vary, not only in texture and color, but also in strength and durability. It is safe to say that there is scarcely a branch of building construction that demands more careful supervision and inspection than that relating to the selection of the stone to be used. If we can judge from results, no such inspection is called for in the majority of cases, or perhaps even thought of; and, after the contract is let, the contracting party is at liberty to palm off such materials as he sees fit, provided the blemishes are not too self-condemning.

A pressure test is made upon a single specimen, and this, worthless as it is, suffices for all—color, strength, and durability of the whole formation—from whence it is taken. Fancy a farmer seeking to sell his still unharvested crops by exhibiting to his customers a single sample each of apple, potato, or whatever it may be, and expecting thus to barter away his whole supply, subjected to no further inspection. Such an idea is, of course, too ridiculous for consideration, and yet this is, in altogether too many cases, what is done in the line of building materials. The contract calls for Maine and Massachusetts granite or Connecticut and Ohio sandstone, and nothing more. We may get good and we may get bad, the chances being in favor of an indiscriminate mixture of both. In all cases where expensive structures are to be erected, every stone should pass under the eye of a competent inspector, fully authorized to accept or reject material as his judgment dictates. Such a position will be found difficult to fill; but it is none the less essential.

A peculiarity that cannot fail to strike one who studies the census returns is the close relationship that exists between the amount of capital invested and the value of the annual product. In very many cases they will be found nearly equal, the variations either way being but slight. This quick return of capital does not, however, denote an extremely well-paying business, but rather one in which the chief outlay is in labor rather than costly machinery and other fixtures. A good quarry in the hands of a shrewd and strong company is undoubtedly a well-paying property, but very many of the smaller ones are merely capable of affording employment to their owners or lessees, at fairly remunerative wages. This last is said to be especially true regarding many of the "bluestone" quarries of New York State.

NOTE ON THE ORIGIN OF COMETS.

By DANIEL KIRKWOOD.

HAVE comets originated in the solar system, or do they enter it from without? This question has been considered by Laplace, Proctor, H. A. Newton, and others. The last named presents arguments of no little weight in favor of their origin in interstellar space.* To these arguments I shall attempt no reply. On the contrary, I have been disposed to accept them as, in the main, valid. For certain comets of short period, however, various facts seem to indicate an origin within the system.

(1.) According to M. Lehmann-Filhes, the eccentricity of the third comet of 1884, before its last close approach to Jupiter, was only 0·2787.† This is exceeded by that of twelve known minor planets. Its period before this great perturbation was about 3,619 days, and its mean distance 4·611. It was then an asteroid, too remote to be seen, even in perihelion. Its period was very nearly commensurable with that of Jupiter, six of the one being very nearly equal to five of the other. According to Hind and Krueger, the great transformation of its orbit by Jupiter's influence occurred in May, 1875. Its present period is about 6½ years. It was discovered by M. Wolf, at Heidelberg, September 17, 1884. Its history indicates an origin in the zone of asteroids.

(2.) *The Second Comet of* 1867.—This body was discovered by M. Tempel, on the 3d of April. Its perihelion distance is 2·073, its aphelion 4·8973, so that its entire path, like those of the asteroids, is included between the orbits of Mars and Jupiter. The eccentricity

* Am. Jour. Sci., September, 1878. † Annuaire, 1886.

of this comet at its successive returns has been as follows:

Date of return.	Eccentricity.
1867	0·5092
1873	0·4625
1879	0·4624
1885	0·4051

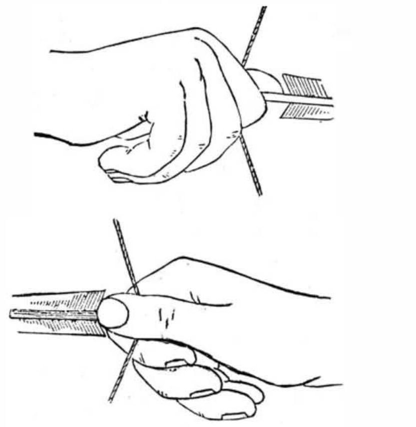
The last is nearly identical with the eccentricity of Æthra, the 132d asteroid (0·38). The period, inclination, and longitude of the ascending node are approximately the same with those of Sylvia, the 87th minor planet.

This comet may be regarded as an asteroid whose elements have been considerably modified by perturbation.

Other comets furnish suggestive facts which bear upon the same question, but their discussion must await the development of additional data.—*Amer. Jour. of Science.*

ARROW RELEASE.*

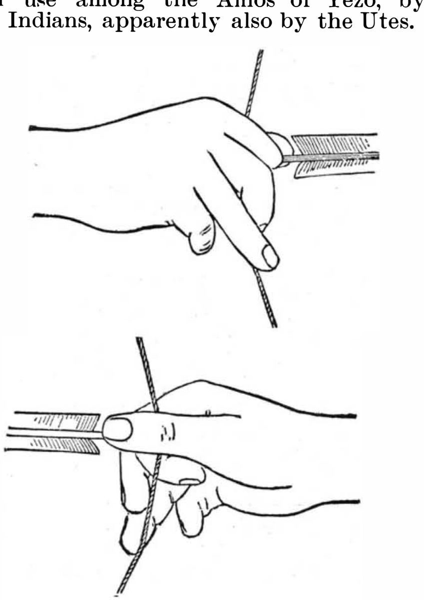
AT the commencement of this very interesting and instructive monograph, Professor Morse tells us that when he began collecting data illustrating the various methods of releasing the arrow from the bow, as practiced by different races, he was animated merely by curiosity; nor was it until he had accumulated quite a



FIGS. 1 AND 2.—PRIMARY RELEASE.

collection of sketches and other memoranda on the methods of arrow release, not only of existing but of ancient races, as shown by frescoes and rock sculptures, that he realized that even so trivial an art as that of releasing the arrow might possibly lead to interesting results in tracing the affinities of races. Hence he publishes in the present pamphlet the data which he has thus far collected, in the hope that further material may be secured for a more extended memoir on the subject. The great difference which Prof. Morse observed between the ordinary English and Japanese methods of using the bow first led him to investigate the subject, with the curious results to be presently narrated. The various forms of release, with their different modifications, are classified, and perhaps Prof. Morse's investigations may be most succinctly described by using his classification.

1. *Ordinary Release.*—This is the simplest form of release, and is that which children all the world over naturally adopt in first using the bow. It consists in simply grasping the arrow between the end of the straightened thumb, and the first and second joints of the bent forefinger (Figs. 1 and 2). With a light or weak bow, says Prof. Morse, this release is the simplest and best; it makes little difference on which side of the bow the arrow rests, provided the bow is held vertically. On the other hand, however, a stiff bow cannot be drawn in this way, unless one possesses enormous strength in the fingers. This simple or primary release is that in use among the Ainos of Yezo, by the Demerara Indians, apparently also by the Utes. The



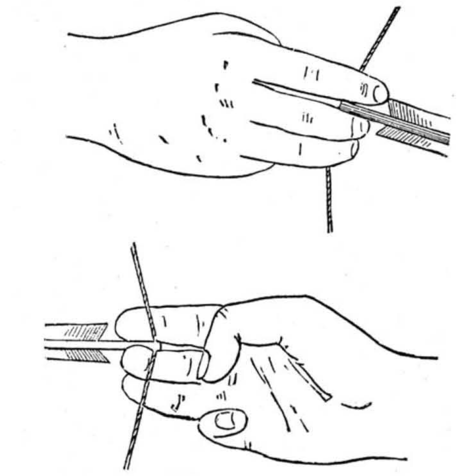
FIGS. 3 AND 4.—SECONDARY RELEASE.

Navajos employ it when shooting at prairie dogs, so that the arrow will not penetrate the ground if it misses its mark; so do the Chippewas. The Micmac Indians of the Cascapedia settlement, on the north shore of the Bay of Chaleur, used it, and it is said that the other tribes in this part of Canada draw the arrow in the same way. A member of the Penobscot tribe at Moosehead Lake seemed incredulous when Prof. Morse told him that there were other methods of drawing the arrow.

2. *Secondary Release.*—This is a direct outgrowth from the primary release. It consists in grasping the arrow with the straightened thumb and bent forefinger, while the ends of the second and third fingers are brought to bear on the string to assist in drawing (Figs. 3 and 4). The Ottawas and Zuni Indians practiced this, as also did the Chippewas of Northern Wisconsin.

3. The *Tertiary Release* differs little from the secondary. The forefinger, instead of being bent, is nearly straight, with its tip, as well as the tips of the second and third fingers, pressing or pulling on the string, the thumb, as in the primary and secondary release, active in assisting in pinching the arrow and pulling it back. This is used among various tribes of American Indians—Sioux, Arapahoes, Cheyenne, Assinboins, Comanches, Crows, and Blackfeet. The Siamese, too, practice this release, with the difference that one finger only is used on the string instead of two. It appears, too, from Mr. Man's recent paper before the Anthropological Institute, that the Andaman Islanders use this method.

4. *The Mediterranean Release.*—This release has been in vogue among the northern Mediterranean nations for centuries, and among those of the southern Mediterranean for tens of centuries, and is the oldest release of which we have any knowledge. It is practiced to day, continues Prof. Morse, by all modern English, French, and American archers, and is the release used by the European archers of the Middle Ages. It consists in drawing the string back with the tips of the first, second, and third fingers, the balls of the fingers cling-

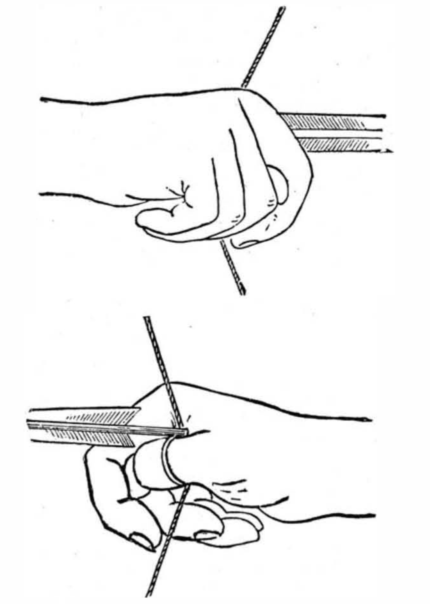


FIGS. 5 AND 6.—MEDITERRANEAN RELEASE.

ing to the string, with the terminal joints of the fingers slightly flexed. The arrow is held lightly between the first and second fingers, the thumb straight and inactive (Figs. 5 and 6). A leather glove or leather finger strings are worn, as Roger Ascham expresses it in his "Toxophilus," published in 1584, "to save a man's fingers from hurtinge, that he may be able to beare the sharpe stringe to the uttermoste of his strengthe." In this release, the arrow must be to the left of the bow, vertical. The Eskimo of Alaska employ this release, using, however, only the first and second fingers in drawing the string, and it appears to be almost universal in the Arctic regions.

These four releases may be considered, Prof. Morse thinks, as successive modifications of each other; but the next release is an entirely independent form, having no relation to the other.

5. *The Mongolian Release.*—In this the string is drawn by the flexed thumb bent over the string, the end of the forefinger assisting in holding the thumb in position (Figs. 7 and 8). The arrow is held at the junction of the thumb and forefinger, the base of the finger pressing the arrow against the bow. For this reason the arrow is always placed to the right of the bow, vertical. This release is characteristic of the Asiatic races, such as the Manchu, Chinese, Corean, Japanese, and Turk. The Persians also use it. The thumb is protected by a guard; the Manchus, Chinese, and others use a thick ring worn near the base of the



FIGS. 7 AND 8.—MONGOLIAN RELEASE.

thumb. It may be made of any hard material, such as horn, bone, ivory, quartz, agate, or jade. The Japanese archer uses a glove consisting of the thumb and two fingers.

These are the principal and most efficient forms of release, although doubtless there are others. Of the methods employed by ancient peoples, as represented in manuscripts, sculptures, etc., the Assyrians at one stage of their history appear to have used the primary form, while subsequently they used the secondary, and still later the Mediterranean release. The ancient Egyptians appear to have practiced three, if not four, definite and distinct methods of release, but many of the representations in the old sculptures are evidently purely conventional, while some are clearly impossible. Following on these, Prof. Morse discusses the methods employed in ancient Greece, Persia, Japan, China, India, Mexico. Here he is naturally on less secure ground, for he has to endeavor to spell out a conclusion from various and conflicting positions of the hand in various ancient graphic representations of life among these peoples. The discussion involves a considerable amount of detail and numerous woodcuts by way of illustration, for which the reader must be referred to Prof. Morse's pamphlet. We must content ourselves with reproducing briefly his conclusions, which, it will be understood, are at present for the most part provisional, pending additional information and wider discussion.

The persistence of a particular release in a people is well illustrated in the case of the Ainos For centuries the Ainos have battled with the Japanese, and must have been mindful of the superior archery of their enemies; indeed, on all hands, with the exception possibly of the Kamchatdales to the north, the Ainos have been surrounded by races practicing the Mongolian release, and yet have adhered to their primitive methods of shooting. The two strongest releases—both perhaps equally powerful—are the Mediterranean and Mongolian, and it is interesting to note that the two great divisions of the human family who can claim a history, and who have been dominant in the affairs of mankind, are the Mediterranean nations and the Mongolians. For several thousands of years each stock has had its peculiar arrow release, and this has persisted through all the mutations of time to the present day. Language, manners, customs, religions, have in the course of centuries widely separated these two great divisions into nations. Side by side they have lived; devastating wars and wars of conquest have marked their contact; and yet the apparently trivial and simple act of releasing the arrow from the bow has remained unchanged. At the present moment the European and Asiatic archer, shooting now only for sport, practice each the release which characterized their remote ancestors. The following classified list shows in a general way that the primary, secondary, and tertiary releases are practiced by savage races to-day, as well as by certain ancient civilized races, while the Mediterranean and Mongolian releases, though originating early in time, have always characterized the civilized and dominant races. The exceptions to this generalization are curious: The Little Andaman Islanders practice the Mediterranean release, and those of the Great Andamans the tertiary; various groups of Eskimo practice the Mediterranean release, and have designed a distinct form of arrow for this method.

Primary Release.—Savage: Ainos, Demerara Indians, various North American tribes; civilized: early Assyrian, Egyptian, and Grecian (?).

Secondary Release.—Savage: some North American tribes; civilized: later Assyrian and Indian (?).

Tertiary Release.—Savage: North American tribes, Great Andamans; civilized: Siamese, Egyptian, Grecian, and Mexican (?).

Mediterranean Release.—Savage: Eskimo, Little Andamans; civilized: European nations now, and the archers of the Middle Ages, later Assyrian, early Egyptian, Arabian, Indian, and Roman.

Mongolian Release.—Manchus, Chinese, Coreans, Japanese, Turks, Persians, Scythians, Egyptians (?).

In conclusion, Prof. Morse expresses a belief that the method of using the bow may form another point in establishing or disproving relationships, in identifying the affinities of past races. Travelers and explorers should not content themselves with observing the simple fact that such and such people use bows and arrows, but they should accurately record: 1, the attitude of the shaft hand; 2, whether the bow is held horizontally or vertically; 3, whether the arrow is to the right or left of the bow vertical; and 4, whether the extra arrows are carried in the bow hand or shaft hand. The method of bracing the bow is of importance also. While anxious to get information respecting the arrow releases of tribes and peoples, he is particularly desirous of hearing about those employed by the Veddahs of Ceylon, the hill tribes of India, African tribes, and those of South America, especially the Fuegians. Such material, in the shape of descriptions, photographs, drawings, and if possible specimens of bows and arrows, may be sent to Prof. E. S. Morse, Peabody Academy of Science, Salem, Massachusetts, and will be acknowledged and used in a future publication on the subject.—*Nature.*

* "Ancient and Modern Methods of Arrow Release." By Edward S. Morse, Director Peabody Academy of Science. Essex Institute *Bulletin*, October-December, 1885.

EVERGREEN SHRUBS.

THE important part of a garden devoted to trees and shrubs should bear inspection from more points of view than one. Collective effect should be secured by the right disposal of the materials, in the shape of trees and shrubs, deciduous and evergreen, which the planter has at command, without which the work must ever be deficient in a leading feature. But although the collective appearance of the trees and shrubs associated is an indispensable feature in this department of gardening, still it is only one of the needful essentials; and though it may satisfy those who see nothing in the cultivation of plants deserving of consideration, except what, for want of a more appropriate term, may be called artistic effect, yet those who can see individual beauty in each tree and shrub are not likely to be content with effect taken in its general sense, but require as much variety in the plants they cultivate as is consistent with their ability to thrive and maintain a healthy appearance. The desirability of securing this will be generally accepted, but in practice it is so far from being generally acted on, that it is rather the exception than the rule. What, for instance, do we usually find in the shape of evergreens in the ordinary run of gardens?—the same laurels, aucubas, cotoneasters, berberis, box, euonymus, hollies, rhododendrons, laurustinus, and others of a like character, represented by the commonest varieties. Whereas all that stands in the way of any ordinary garden of moderate size containing ten times the variety, with a proportionate increase in the beauty and interest attached, is a non-acquaintance on the part of those who own gardens with the quantities of beautiful plants now within reach, and the little apparent disposition of many who are intrusted with planting to go beyond what was done when the number of species now at the planter's command were yet unseen in the wilds where nature placed them, and the many fine seedling varieties that have been raised were non-existent. Possibly a few words respecting the most desirable of the less known kinds and the best of the commoner sorts of

evergreen shrubs may be of use to some who wish to make their gardens more interesting.

The Laurel (Cerasus) has ever been a favorite. The common kind is still most planted. Yet this is a mistake, inasmuch as there are two or three others that have all the good properties of the old one with none of its defects. The character of their leaves is so far like that of the old sort, that the uninitiated would not see the difference, but their general habit is better, and the growth closer and less straggling; while their hardy nature is such that they bear our severest winters without injury in the way that the common kind suffers. Of these, C. Laurocerasus rotundifolia, C. L. caucasica, and C. L. colchica are all fine sorts that only require to be sufficiently known to insure their finding a place in every shrubbery. The first named of the above, C. L. rotundifolia, may be set down as the best, taking all its properties into account. C. lusitanica (the Portugal laurel) is one of the best known of evergreens, and is always a conspicuous object, either massed in the shrubbery or as a single specimen on the lawn, where its dense habit of growth and healthy, vigorous appearance, thriving as it does in almost any locality, will always insure it a place. C. lusitanica myrtifolia, the small leaved variety of the last named plant, is compact in growth and suitable for using where the type is too large.

Arbutus (the strawberry tree).—The common A. Unedo is met with in most gardens. Independently of its beautiful red fruit, which it produces freely in some places, while in others it does not bear, its appearance is such as to make it still deserving of being cultivated generally. A. Andrachne, another fine kind, is not so much grown as A. Unedo, although long in the country. It is a distinct looking and beautiful plant, a stronger grower, attaining a much larger size than the common species, and one which might with advantage be more used by planters than hitherto.

Andromedas.—The commoner kinds of these shrubs are too well known to require any remarks, but there is one which, though long enough introduced, is not so much planted as it should be—A. floribunda. Where a dense, compact growing, low shrub is required it has few equals, independent of the profusion of pretty white flowers with which it is annually clothed. A. japonica is a desirable kind; its panicles of white flowers are effective, while the habit of the plant gives it a distinct appearance. A. formosa is also a desirable sort.

Azara microphylla.—This is one of the most distinct of all evergreens in cultivation. Its slender branches, densely furnished with neat foliage, spread out as flat as the feathery fronds of a fern. It is one of the best and most suitable of all plants for clothing a wall, the protection of which is an advantage, as its ability to bear a severe winter in the open ground is doubtful.

Aucubas.—The old spotted leaved female A. japonica maculata is one of the best known and most useful plants ever introduced to British gardens, and its presence is more acceptable now when there is the means of having it annually furnished with beautiful red berries, by simply planting here and there among the females a plant of the male variety, of which there are different forms, each of which is handsome. It does not require many, even in a large place, to insure a crop of berries, yet there are many gardens where only the female exists.

The Bay (Laurus nobilis) is one of the best evergreens we possess, and never looks more at home than when located against a wall of a building, the shelter of which preserves it from the effects of the occasionally low temperatures that visit us, and which, even in the south of England, often make sad havoc with this plant when growing under conditions more conducive to vigorous growth than well ripened wood.

Berberis.—Most people are acquainted with the charming B. Darwini, which is undoubtedly one of the finest evergreen flowering shrubs existent. Although in parts of the kingdom less favored by climate it suffers from occasional low temperatures, nevertheless every one should grow it; as also the beautiful hybrid B. stenophylla, which has few equals as regards the elegance of its slender drooping shoots, that when furnished with their strings of yellow flowers are extremely effective. This plant should be in every garden.

Buddleia Globosa.—If only for its appearance, which is so distinct from that of all other plants, this buddleia is worth having. In many parts it will not stand the winter in the open ground, but, wherever room can be found for it on a wall, it deserves a place. Its perfectly globular flowers give the plant an appearance like nothing else that I recollect. When grown against a wall, it should not be pinned in too closely in the way sometimes practiced. Allow it more liberty, simply keeping the branches from getting too far away to admit of the protective influence of the wall.

Cotoneasters.—The value of C. buxifolia and C. microphylla for covering walls or rockwork is generally known, and of C. simonsi, the red berries of which brighten up the shrubbery in winter. Another kind, C. roylei, may with advantage be added to those previously named.

Cistus.—C. ladaniferus (the gum cistus), although a very old plant, is not so common in gardens as the distinct character of its charming flowers might lead one to expect. Even in places where it suffers in hard winters it deserves the little labor that is involved in giving it the necessary protection during severe weather.

Garrya Elliptica.—Though this plant is devoid of the gay colored flowers that many possess, still there is a peculiar elegance in its long, drooping catkins that is attractive and different from everything else I have seen. It does well on a north wall, where few things would succeed.

Choisya Ternata.—When better known, this plant can scarcely fail to become a favorite. In those parts of the kingdom where it will succeed, it well deserves a place among the most select wall plants, protection of which kind it most likely will require.

Ceanothus.—Of these there are now a good many varieties besides the better known sorts, such as C. dentatus and C. azureus. C. azureus albidus, C. Devoniensis, Gloire de Versailles, C. floribundus, and C. Veitchianus are all handsome kinds, but, even in the southern parts of England, they should have the sunny side of a wall.

Desfontainea Spinosa.—If one were to imagine Osmanthus ilicifolius bearing small flowers of Lapageria rosea, it would give a tolerably correct idea of what Desfontainea spinosa is like when in bloom. Unless in the mildest parts of the kingdom, it is not safe without the protection of a wall, which it well deserves. The aspect should be south. Being a slow grower that does not attain a large size, little space will suffice for it.

Daphne Cneorum.—In the whole range of fragrant flowers, it would be difficult to point to any plant that surpasses this little gem. It is just the sort of plant that any one who has a garden might be supposed to grow, yet it is a question if it could be found in one place out of fifty. The little room it occupies, which is not more than that required by the common perennial Candytuft, puts it within the reach of those who have not much space at command.

Box.—The ability which the common Box has of maintaining a fair appearance when under the shade of trees where few plants can live is sufficiently understood, and as a dense, healthy looking shrub when it receives better usage it will always keep in favor. There are several varieties that should not be lost sight of. Handsworthiana is a useful sort, and also the gold and the silver varieties of the common kind; japonica aurea is remarkable for its clear yellow color, and the strong growing balearica deserves planting in localities where the winters are not too severe.

Escallonias.—Unfortunately, the beautiful Chiloean species, E. macrantha, is not hardy enough to show its true character except in the mildest parts of England, but it makes a good wall plant in most of the southern counties, though even under such conditions it sometimes suffers from exceptional frosts. E. Phillipiana is a comparatively new introduction from the Andes; it is a distinct and pretty species, bearing numbers of white flowers, which are well set off by the neat foliage.

Eugenia Ugni.—Although this shrub failed to realize the expectations held by some when it first appeared of its turning out a useful edible fruit, still its general appearance, which is well enhanced when in berry, is such as to make it a desirable plant.

Euonymus.—The Japanese kinds of Euonymus have turned out valuable shrubs for the various purposes which they can be used for. E. japonicus is one of the best evergreens for planting in and about towns, and it is an excellent plant for use near the sea. The golden and the silver variegated forms as well as the green kind are among the best evergreens for covering a wall; while the little E. radicans variegatus, besides being one of the best edging plants we have, is an excellent subject for a wall, reaching a height which its humble appearance when trailing on the ground would scarcely lead one to expect.

Laurustinus.—This old favorite is too well known and well proved to require anything to be said in its favor. Its ability to thrive almost anywhere, together with its healthy appearance and the profusion of pretty flowers it bears when there is little else to enliven the shrubbery, will always insure its being largely planted.

Ligustrum.—L. vulgare, the common Privet, is one of the best known plants for a screen or hedge about gardens or grounds where ability to resist cattle is not required. For the purposes named its neat appearance befits it. But L. ovalifolium, the oval-leaved kind, which is much stronger in habit and one of the quickest growing shrubs we possess, is supplanting the old variety. It is one of the most useful evergreens for town planting, its vigorous constitution enabling it to thrive where few things can live. L. coriaceum and L. japonicum are both distinct and desirable plants for shrubberies.

Magnolias.—M. grandiflora is one of the most remarkable evergreens we have, and one of the best plants for a wall in the south of England where a considerable space has to be covered. Its large glossy foliage is very handsome, and equally so are the massive fragrant white flowers which the plant produces freely when in good condition. It is not well to trust it away from the protection of a wall except in the most favored localities. In the northern counties it sometimes suffers when on a wall, unless protected in exceptionally severe winters. The Exmouth variety and M. ferruginea are both desirable plants, requiring similar treatment.

Osmanthus.—O. ilicifolius, with its gold and silver variegated forms, are desirable plants, best adapted for standing in the front of large growing things, as they never get coarse or attain a size such as to encroach on other plants. O. myrtifolius and O. rotundifolius are also handsome.

Phillyreas.—The contrast which these plants present to things with massive foliage, combined with their ability to thrive in most localities, are the chief merits which they possess, and will doubtless still keep them in favor, although planters are not now confined to the limited field we had to choose from when these old fashioned evergreens were first introduced.

Rhamnus.—These plants are more interesting than striking in appearance, but are worth having to give variety. R. angustifolius and R. latifolius, with its varieties, are among the best deserving of the planter's notice.

Skimmias.—Among berry-bearing shrubs S. oblata holds a first place, but it is diœcious and a female, consequently, to secure berries, the male, S. fragrans, requires to be planted with it. The hermaphrodite form usually sold as S. japonica, which is more generally grown, so far as my experience in a good many localities goes, is not near so desirable a plant as S. oblata, but no harm will be done by having all three. These and other small growing plants are not enough used at the outer edge of clumps and shrubbery borders, large coarse growing things often being planted instead. The result of this is that they get too big for the positions they occupy either to look well or to be allowed to remain.

Ulex (Gorse) is too common a plant to suit every one's taste, yet there are few gardens where the double variety might not with advantage be more freely introduced to the front of shrubbery borders than it usually is. When rightly placed, its dense sheet of yellow bloom lights up everything near it.

Ilex.—It may be safely said that there is no evergreen which plays a more important part in decorative planting than the British Holly with its numerous varieties that have appeared in the form of seedlings and sports, in which latter direction it has a greater tendency than many things. The type will ever be a favorite from its excellent properties and the varied purposes to which it can be turned, but there are several other green leaved sorts that are especially deserving of notice for their handsome appearance. Of these may be named I. Hodginsi, I. laurifolia, I. Shepherdi, I. ferox (the Hedgehog Holly), I cheshuntensis, I. donningtoniensis, I. myrtifolia, the yellow-berried, and the Weeping Holly. Of the variegated varieties, Gold and Silver Queen, aurea marginata, argentea, Handsworthensis, aurea picta, and alba picta, the Gold and Silver Milkmaids, the gold and silver forms of I. ferox, Waterer's dwarf golden, and the gold and silver weeping varieties are all good. Other kinds that deserve notice are I. balearica, I. maderiensis, and I. opaca. The above are the cream of the Ilexes, though there are others that any one desirous of growing a collection might be inclined to add.—*T. B.*, *The Garden.*

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