SCIENTIFIC AMERICAN SUPPLEMENT No. 588

Scientific American Supplement, Vol. XXIII., No. 588. Scientific American, established 1845.

NEW YORK, APRIL 9, 1887.

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

EXPERIMENTS ON WHIRLWINDS, WATER-SPOUTS, AND REVOLVING SPHERES.

At a recent session of the French Academy of Sciences, Mr. Mascart described some interesting experiments which Mr. Charles Weyher has lately performed on the artificial reproduction of whirlwinds and waterspouts, and which are as follows:

1. *Waterspouts.*—A drum three feet in diameter is mounted upon a vertical axle, which is set in revolution through a pulley and belt (Fig. 1). This drum is provided internally with six or eight radiating pieces. It is open beneath, and its rotary velocity at the circumference is from 90 to 120 feet per second. This apparatus is placed about ten feet above the surface of some water contained in a large reservoir. As soon as the drum is revolved, spirals are observed to form on the surface of the water and to converge toward the same center, where a large cone, 8 in. in diameter and 4 in. in height, then makes its appearance. This first cone is surmounted with a second and reversed one, formed of numerous drops, that rise to a height of, say, from 3 to 5 ft., and fall all around at distances varying from 3 to 10 ft. The finest drops of water rise as far as to the drum.

If straw be put upon the water, it will be drawn together by the vortex, and will form a sort of cord, that will rise spirally in the axis of the vortex. If a wet board be placed upon the water, the vortex will form upon it a focus of, say, three-quarters of an inch in diameter, and of a whitish appearance, while a peculiar whistling will be heard, as if the board contained an aperture through which a mixture of air and water was passing upward with great force. It is remarkable to see the vortex concentrate and contract on the board to a diameter of but ⅛ or ¾ of an inch, while the divisions of the drum leave at the center of the latter a free circle of 15 inches in diameter.

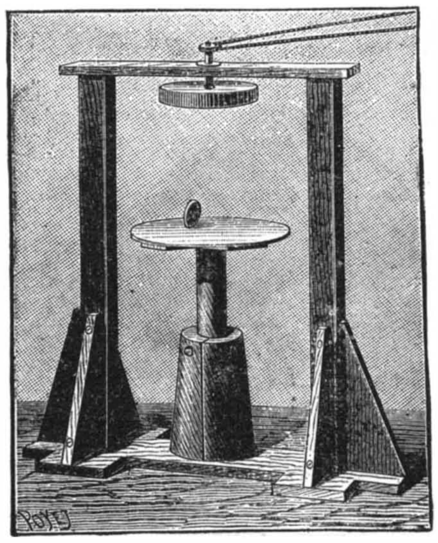


Fig. 3.—COIN HELD A PRISONER IN A VORTEX.

It is easy to demonstrate that the artificial whirlwind created by the drum presents exactly the same characters as the lower part of an atmospheric vortex that has descended from the upper regions to the surface of water.

As this experiment is performed in the open air, the focus quite easily shifts under the influence of the least wind, and it is, therefore, difficult to study it well. It may, therefore, be performed on a smaller scale and with a closed vessel; but the open air experiment shows that the closed vessel is not the cause of the formation of a focus, it having no other effect than that of permitting of fixing the axis of the vortex at nearly the same point.

2. *Aerial Vortices.*—A glass cylinder, about 15 inches in diameter and 24 in length (Fig. 2), is provided with a cover containing an aperture through which passes an axle furnished with one or two cardboard vanes mounted crosswise. The cylinder contains sawdust or, what is better, oatmeal. If the latter be first so arranged as to form a cone or hillock, and the axle be revolved, we shall see an imitation waterspout form at the apex, and the mass of meal will gradually hollow out into a hemisphere. The material will incessantly run in spirals from the circumference to the center, where it will first form the lower cone, and then the reversed one, whose particles of meal will describe spirals running from the center to the circumference.

The system, as a whole, forms a general, more or less distorted sphere, whose focus (where the two cones meet) is also put out of center to a certain degree by terrestrial gravity. If we examine things from above, we shall see a hollow funnel on the axis. It is here that the air is most rarefied through rotation, and it is hither that the finest portion of the material comes.

Substituting small, light balloons inflated with air for the oatmeal, let us follow the general motion. When the balloons reach the external circumferences, they slowly descend in spirals, and when they reach the circumferences contiguous to the axis of revolution, they quickly rise on a helix of more or less elongated pitch. Upon the whole, the experiment shows that, being given a mass of air, if we communi-

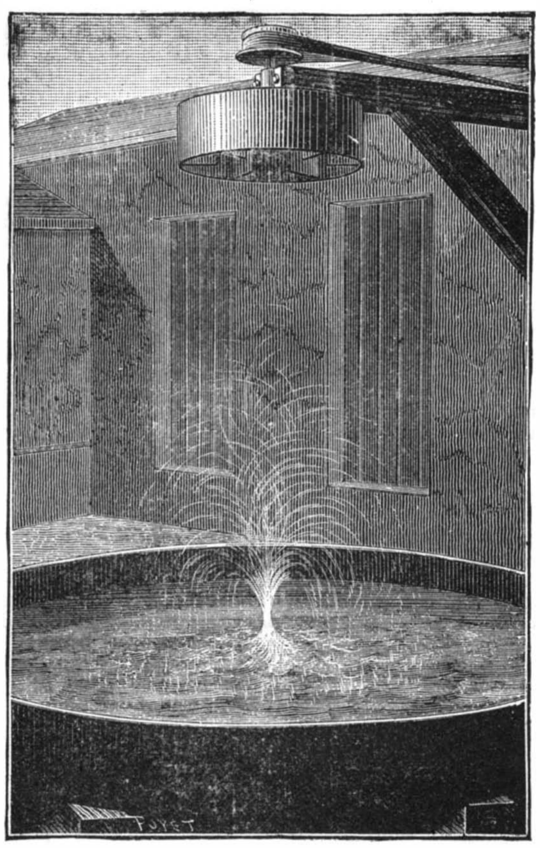


Fig. 1.—APPARATUS FOR PRODUCING AN IMITATION WATERSPOUT.

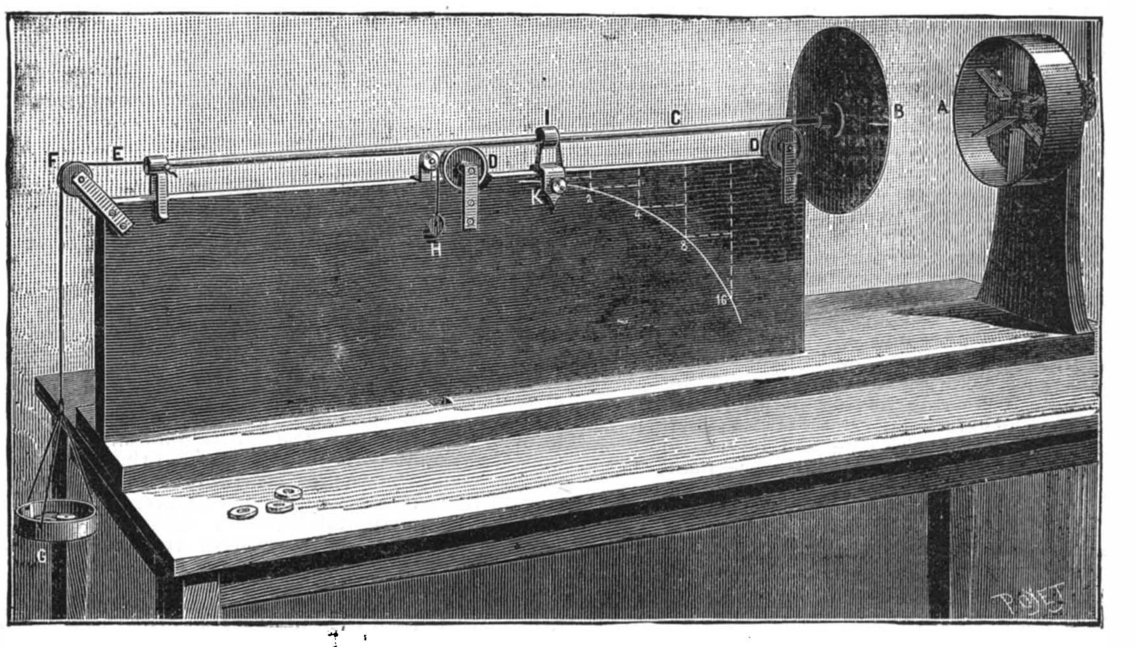


Fig. 4.—EXPERIMENT TO SHOW THE ATTRACTION PRODUCED BY A VORTEX.

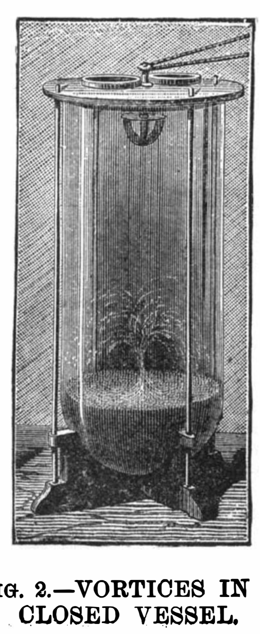


Fig. 2.—VORTICES IN A CLOSED VESSEL.

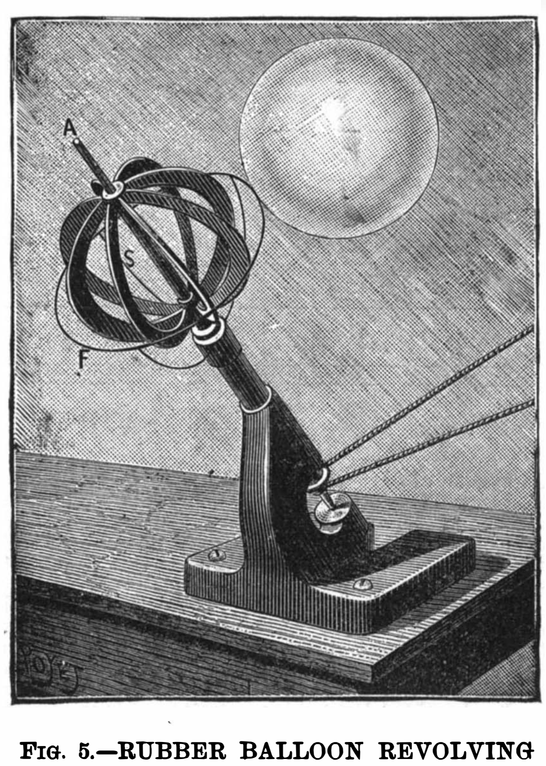


Fig. 5.—RUBBER BALLOON REVOLVING AROUND A RAPIDLY ROTATING SPHERE.

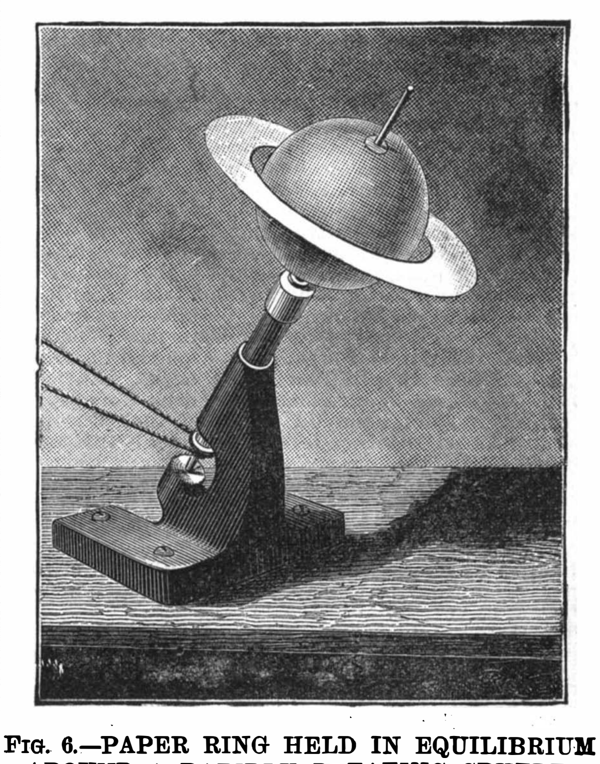


Fig. 6.—PAPER RING HELD IN EQUILIBRIUM AROUND A RAPIDLY ROTATING SPHERE.

cate a rotary motion to it around a vertical axis, it will constantly descend through the external circumferences and rise again through the internal ones, and the entire volume will continuously pass through the focus of the vortex, carrying along with it in its motion the particles that are involved in it.

3. A disk of glass or of any other material is placed beneath an axle provided with vanes. After this device has been set in motion, a coin is made to spin along one of its diameters (Fig. 3). After the hand has been taken away, the vortex continues to make the coin spin like a top, and absolutely holds it captive within its radius of action. The coin, in spinning, generates a sphere, and a subsequent experiment will show that a revolving sphere constitutes a center of attraction.

4. The experiment illustrated in Fig. 4 is designed to measure the attraction produced by a vortex. A is a device analogous to the one shown in Fig. 1. B is a cardboard disk affixed to a very light rod, C, that revolves upon two very loose pulleys, D. A thread, E, passing over a pulley, F, supports a scale pan, G, which is balanced by a weight, H. I is a stop fixed upon the rod, C. K is a slider provided with a fork that affords a slight play to I.

The drum, A, is made to revolve with a uniform motion. By means of weights put into the scale pan, G, and on seeking with the slider the corresponding positions of equilibrium, it is found that the attractions upon the disk, B, are in inverse ratio of the square of the distances. With the same apparatus, and with the aid of a balloon supported by a thread, we may likewise ascertain the lateral attraction of the vortex.

5. *Equilibrium of Revolving Spheres.*—A free sphere remains in equilibrium and revolves around another sphere having a rapid rotary motion (Fig. 5).

The apparatus consists of a spindle, A, capable of revolving in a support and provided with a pulley driven by a cord. Upon this spindle is mounted a sphere, S, composed of eight or ten rings, which may be either entire or in the form of semicircles. The spindle may occupy any position whatever with respect to the horizon. In this experiment, it is inclined at an angle of 45°, but it may be horizontal or vertical. The angle of 45° is chosen as seeming to offer the most difficulty in the way of carrying out the experiment, in order that the latter may be conclusive.

When the sphere, S, is rapidly revolved, the hand feels a strong breeze escaping through the equator on every side. If bits of paper be presented, they will be blown to a distance. Nevertheless, if a balloon be presented, it will be strongly attracted toward the revolving sphere, and will describe orbits around it in the plane of the equator. As this experiment is performed in a room where there are obstacles that produce disturbances, and as gravity, too, has too great an influence, by reason of the earth's proximity, it is very difficult to get things to run regularly. The balloon readily comes into contact with the revolving sphere, but is repulsed by the shock to too great a distance to be recaptured. A very simple artifice consists in placing around the sphere, S, a wire ring or guard, F, 0·04 in. in diameter, fastened to the support by three wires of the same diameter.

The balloon then revolves indefinitely around the sphere, and, in doing so, even leaves the guard at the lower part under the action of gravity. The experiment may be arranged in different ways, and we may even do away with the guard; but such variants teach us nothing further.

Upon studying the whirling motions produced by the sphere, we may readily find out the reason of the attraction that it exerts upon the balloon.

6. If we remove the guard from the revolving sphere, and present a paper ring (having an internal diameter greater than the external diameter of the sphere) parallel with the equator, the ring will be caught in the rotary motion and be firmly held in the plane of the equator.—*La Nature.*

RECENT PHENOMENA ON THE SURFACE OF MARS.

THE planet Mars has for a long time attracted the attention of observers through the remarkable features of its constitution. Owing to its relative proximity, the telescope has been able to furnish us with a host of data concerning its physical geography, and even its meteorology. This planet, as well known, exhibits spots—some of them brilliant, and others dark, which there is reason to consider as continents and seas (Fig. 1).

Toward the poles are seen great white zones, sometimes small, sometimes large, which are masses of ice that sometimes break up like our terrestrial icebergs. The limits around the boreal pole are marked with them toward the bottom of Fig. 1 for the year 1879. In the tenuous and transparent atmosphere, we recognize clouds and currents, and often whirlwinds very much like those cyclones that let themselves loose with us.

In addition to these intimate analogies with the earth, the study of Mars reveals special peculiarities, some of which are explained by the most satisfactory considerations of comparative geology. With the tenuity of the atmosphere is associated a more limited extension of the seas, and the relative distribution of dryness and moisture is very different from what it is upon the earth. On the surface of our planetary neighbor, astronomers point out, as one of the most remarkable peculiarities, the large number of long and narrow passes and seas shaped like bottle necks. As well known, the oceans on our globe have thrice the area of the continents, and it should be noted that Europe, Asia, and Africa together form a single great island, while another one is formed by the union of the two Americas. Now, on Mars there is an almost complete equality between the surfaces occupied by the continents and seas. Moreover, the latter are intermingled in so complicated a manner that a traveler might, either by land or by boat, visit nearly every quarter of the planet without having to leave the element upon which he began his voyage.

This stated, it is necessary to recall the fact that Mars is older than the earth, that is to say, having individualized itself more anciently than the latter, it has reached a more advanced stage of sidereal evolution; so that this planet now represents, in its broad features, and independently of its individual characteristics, a state that the earth will reach in the hereafter. Now, one of the inevitable effects of the secular cooling of the earth is to cause a progressive absorption of the water of the oceans by the successively consolidated masses of rock. Hence an eloquent comparison can be made between the present seas of Mars and the terrestrial oceans supposed to be in great part absorbed. The results of innumerable soundings have allowed of bathymetric charts being drawn, and it is now thirteen years ago that I pointed out the bottle neck shape of the Atlantic Ocean 13,000 feet below its present surface. If, then, we suppose the water of the Atlantic absorbed by the rock masses at this moment in process of solidification, so that the level of the ocean lowers by 13,000 feet, we shall at once have a much smaller surface covered with water, and a narrow and elongated form of the sea, that is to say, exactly the features presented by Mars.

But it is since that magnificent work was published that the author, during the last opposition of Mars, in 1881–1882, observed the wonderful phenomena depicted in Fig. 2, which is taken from a memoir that has not yet been published, and the communication of which I owe to the extreme kindness of Mr. Schiaparelli. It appears from these observations, and from those made by him between 1884 and 1886, that the surface of Mars is at present the theater of gigantic phenomena which, in the course of a few years, will suffice to profoundly change its aspect.

It will be seen from the figure, in fact, that many canals hitherto described are dividing into two, and are accompanied as it were with a second, similar in dimensions and direction. In order to produce such an effect, one of our most eminent areographers, Dr. Terby, of

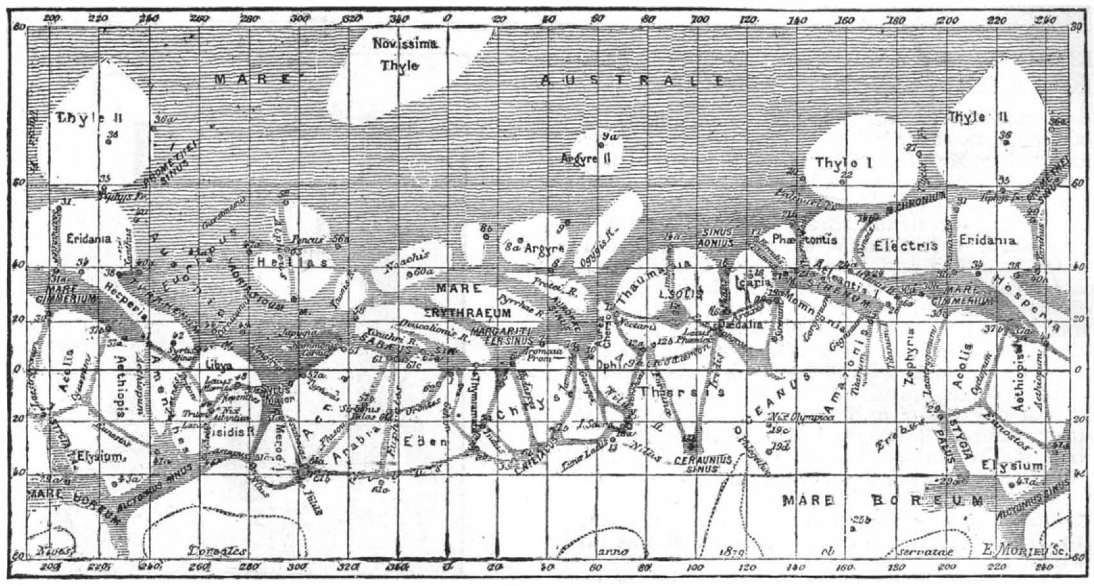


FIG. 1.—MAP OF MARS DRAWN IN 1879.

Louvain, who has just set up a fine eight inch, equatorially mounted Grubb telescope at his house, in view of the approaching opposition of Mars, has discovered a very just comparison. Let us move in proper position over Fig. 1 a doubly refractive crystal—one of Iceland spar—and we shall see the canals subdivide as shown in Fig. 2.

While the water is being taken up in this way, the air itself must be absorbed. All rocks are aerated. We know how difficult it is to drive the air from a rock (even the most compact one) whose density we desire to obtain with accuracy. As the various mineral masses become aerated while they are being wet, and consequently while they are cooling, the atmospheric stratum must progressively decrease. It is natural, then, that the atmosphere of Mars should be much more tenuous than that of the earth, and this, by the way, is an excellent condition for the telescopic study of our planetary neighbor.

As regards the earth, geology furnishes a sort of indirect confirmation of this successive absorption of the atmosphere. It results, in fact, from the experiments of physicists, of Mr. Tyndall especially, that a slight increase in the thickness of our atmosphere, or in the proportion of vapor that it contains, would suffice to cause a greater quantity of solar heat to become stored up therein and to be dissipated more slowly. That is to say, what we call climates would disappear, as a warm and but slightly variable temperature would extend over the entire globe.

Now one of the most remarkable characters of the ancient geological periods was precisely such absence of climate, as is shown by the uniformity of the faunas and floras of the entire planet. Herein we may see a confirmation of our opinion that the air then formed a much thicker stratum than it does to-day. But, although some features in common evidently exist between the earth and Mars, a great interest resides in the existence on the surface of the latter of these globes of very important details of structure, which are without analogy with us. As long ago as 1877, Mr. Schiaparelli began to perceive in the continents of Mars, which until then had been immense and continuous, a system of dark canals, often very narrow, which divided its surface into a multitude of lands which were isolated and separated from each other like the meshes of a net. This is very well shown in Fig. 1, where may be read the names of a certain number of these canals. These latter, despite their apparent tenuity, were not less than 72 miles in width. In length, several of them reached 2,880 miles. These results at first excited nothing but incredulity in astronomers, who were soon, however, obliged to recognize their perfect accuracy. The illustrious director of the observatory of Milan has been good enough to remit me his works, the last of which, relating to the opposition of 1879–1880, forms a voluminous quarto memoir of 109 pages, with 6 plates, and the reading of which is highly interesting.

This phenomenon, which is without analogy, Mr. Schiaparelli calls the gemination of the canals, and he is preparing an extensive memoir in regard to it which will soon appear. These astonishing discoveries, which were at first received with incredulity, are being newly confirmed, as shown by the observations of Messrs. Boeddicker and Burton, in Ireland, and especially by those of Mr. Perrotin, director of the observatory of Nice, with the aid of Messrs. Trepied, Thollon, and Gautier. Other observers, such as Messrs. Green, Knobel, and Denning, have not been so fortunate in the verification of the facts, and yet their researches, published in the memoirs of the Astronomical Society of London, and in the monthly notices, are full of interest.

What further adds to the mystery is that the gemination seems to be taking place gradually. Thus, to cite but one example at the side of the canal styled Nilus, astronomers some time ago found a second one parallel with it, called for this reason Nilus II. This was very feeble, and, as sketched in the chart shown in Fig. 1, is hardly visible, but now, as shown on the last chart (Fig. 2), the two Niluses have a very nearly equal intensity.

Mr. Terby, on studying comparatively the admirable drawings made a century ago at Lilienthal by the celebrated astronomer Schroeter, and a little farther back by Herschel in England, has met with analogous modifications of Mars' surface. Among these are some local

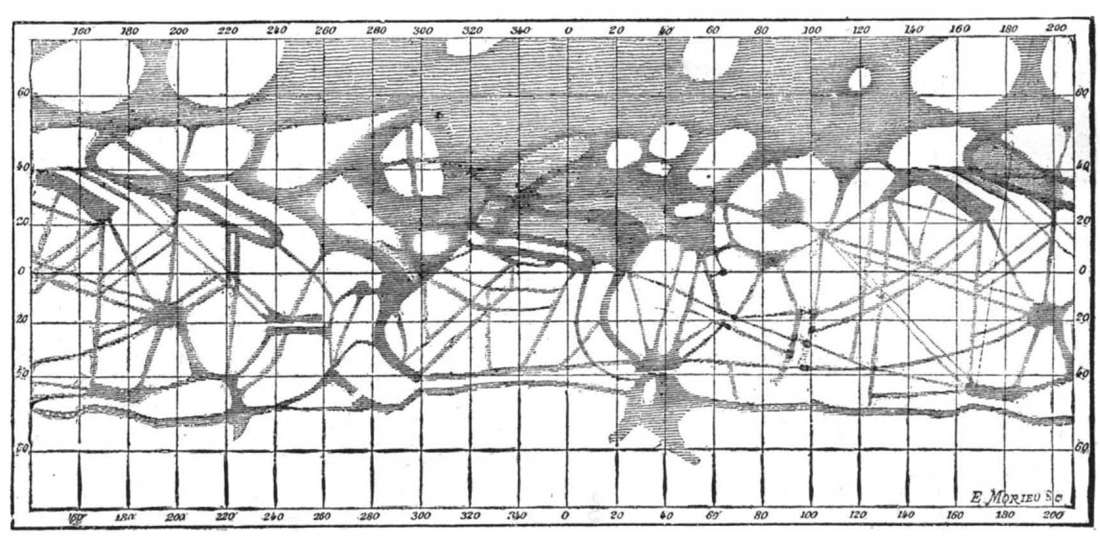


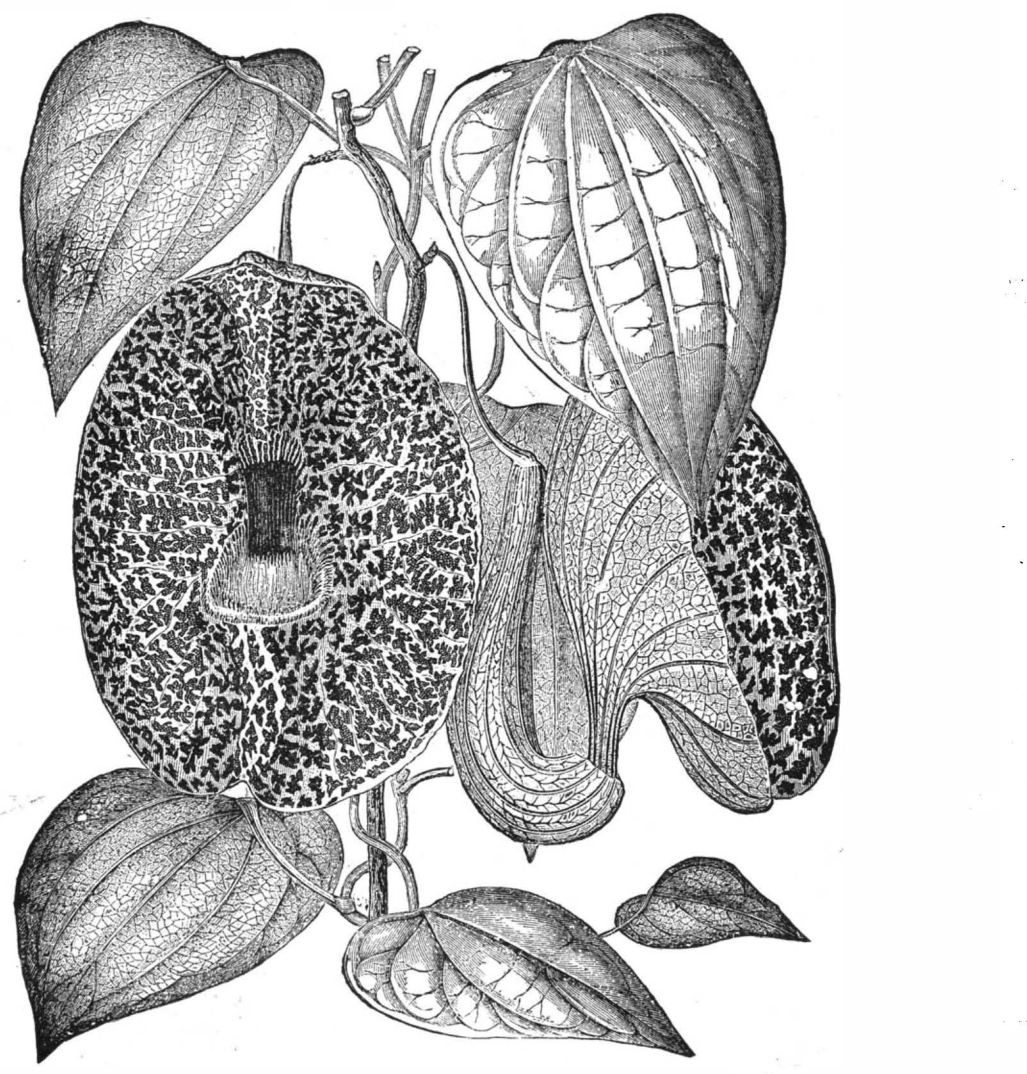
FIG. 2.—MAP OF MARS DRAWN IN 1886.

enlargements of certain seas, such as that of Kaiser, and other changes of detail in the configurations of the planet which until then had been supposed to be fixed. In the same direction, we must mention a memoir by Mr. Van de Sand Baghuyzen in the annals of the observatory of Leyden, in which the author interprets all the drawings of Schroeter, and at the same time finds therein the trace of a host of Mr. Schiaparelli's details. Finally, Father Lamey has made numerous observations of Mars, which have led him to results of extreme originality, and the prompt confirmation of which is much to be desired.

As may be seen, the wonderful studies of which Mars is the object are opening up entirely new horizons to astronomy.—*S. Meunier, in La Nature.*

THE ARISTOLOCHIA CLYPEATA.

WE can realize the difference between the temperate and the torrid zones better by a comparison of the plants of those species which belong to both zones than in any other way. Two species of the genus Aristolochia, viz., Aristolochia clypeata and Aristolochia elegans, were found in South America (New Granada and Brazil). The former only of these is shown in the accompanying cut, taken from the *Illustrirte Zeitung*. One who is versed in botany is reminded, when he sees this gigantic flower, of the German A. clematitis, L., with its small yellow flowers, or the A. sipho of North America. The flowers of these plants are scarcely larger than half an inch, while the flowers of the South American species are immense. Several other South American plants of this genus can be mentioned as examples. The first of these which was known was the A. cordiflora, discovered by Humboldt and Bonpland on the Magdalena River in New Granada. The flowers of this plant measure about 15 inches in diameter. The second one was found in Brazil by the Munich botanist Martius, who named it A. gigantea. The A. clypeata does not reach quite such gigantic proportions; the tube which takes the place of the calyx is from 3 to 4 inches long, while the shield-shaped flower is 7 inches long and 12 inches wide. Another species is found in the primeval forests on the Amazon, the flowers of which are more bell-shaped, and are from 3 to 5 inches in diameter. These species are good examples for illustrating the effect of light, heat, and dampness on the development of large flowers. There is, besides, a wonderful freak of nature to be found in the coloring. The fantastic forms and colors of the orchids are familiar to us all, but even greater wonders are seen in the Aristolochiaceæ, which should be exhibited as often as possible, that we may better understand the power of the tropical sun.



ARISTOLOCHIA CLYPEATA.

THE POTATO AT REST.

WE are so accustomed, at this season, to think of the potato as an inert object when at rest, that we are apt to overlook the fact that the rest is only partial, while underneath that impassive and immobile looking skin a good deal of work is going on—at least, whenever the temperature is above freezing. Some knowledge of the nature of that work is desirable for us as practical men, because upon the way in which it is done depends, in great measure, our success in storing potatoes for consumption, and the vigor and health of our crops for the future. Much of the complaint made of late as to the degeneracy of the potato, and as to its inferior quality as compared with past times, is probably due to the way in which these changes are effected. These again are dependent upon the way in which the plant was able to do its work in the preceding summer. This brings us to the questions whether the newer varieties are as well adapted to our climate as the older ones, and whether the exhibition table has not something to answer for by fostering good looks at the expense of constitution; at any rate, these matters are worth consideration. If an ordinary grower of, or dealer in, potatoes were told that the tubers he rightly sets such store by breathe as human beings do, he would probably think that some facetious hoax was being played upon him. The fact, however, remains that, although they have no lungs, potatoes, in the ground or out of the ground, breathe. We do not mean to say that they palpitate, draw long breaths, or heave deep sighs, but they breathe nevertheless. They inhale and exhale through their skin gases of various kinds, just as every one knows that under certain conditions they exhale moisture, or "sweat." The conversion of the sugary juice called glucose, derived from the foliage, into the solid starch stored up in the tuber is associated with the emission of gases, while the reconversion of that starch into soluble sugar requisite for the maintenance and nourishing of the tissues of the tuber, and for the shoots when growth commences, is also attended by an emission of carbonic acid gas and watery vapor, this latter process being more or less analogous to that which constitutes the respiration of animals; and thus it is that potatoes breathe. Starch grains are practically insoluble, and are too large to be conveyed in their solid form from the leaves in which they are formed to the tubers in which they are to be stored up; hence the necessity for their conversion into glucose, or some analogous liquid matter by means of which the transit may be made, and from which the solid starch may be again deposited as occasion may require; so that potato tubers, whether still in the ground, or removed and placed on the exhibition table, or in the cellar, are, in a certain way, breathing.

The chemical changes we have alluded to go on probably through the agency of some ferment in the detached tuber in the same manner, but to a less extent than when it is still attached to the plant. A kilogramme (2 lb. 2 oz.) of potatoes when the temperature was 20° C. (68° F.) gave off, in August, 6·5 milligrammes of carbonic acid per hour, and in January and February, at the same temperature, 10 and 11 milligrammes per hour. When exposed, however, to the freezing point in the laboratory, whether in August or in the winter months, the proportion of carbon dioxide, *alias* carbonic acid gas, was reduced to about two milligrammes per hour. As the temperature rises, more and more sugary juice is found in the tubers, less and less starch. A time comes when the sugar is no longer used up in the course of the respiratory process, and no longer converted into starch. An excess of sugary juice then occurs, which flows to the eyes or buds, and the period of comparative rest is at an end. The practical inference is that which careful practitioners have long arrived at from experience, viz., to store the potatoes in a uniform low temperature, in a dry condition, and in the dark, so as not to excite those chemical and physical changes associated with growth, and consequent upon the conversion of starch into sugar. Mr. H. Muller, who has investigated these matters, has extended his researches to the buds of trees, in which exactly the same phenomena take place as in the tubers of the potato. When the flow of sugary juice from the leaf ceases at the end of autumn, and is deposited in the form of starch in the buds, bark, and young wood of the tree, growth ceases. In the spring a little of the sugary juice left over in the bark flows toward the buds, which forthwith begin to swell and lengthen into shoots.—*Gardeners' Chronicle.*

MOTION GIVEN TO THE AIR BY THE WING OF A BIRD.

OBSERVATION has shown that certain birds can rise without preliminary impulse, with the axis of the body nearly vertical, and consequently giving their wings a nearly horizontal motion. The wing must then produce at this initial instant of flight a violent current of descending air, the reaction of which coming up from below will raise the bird's body. It is known, moreover, that if a bird's wing or fan is vibrated in the air, the air escapes lengthwise of the surface striking it. M. Muller attributes this effect to the fact that a stratum of air is compressed against the surface of the moving wing, flows rapidly in the direction of the flexible edge of the wing, and carries after it a certain mass of air, communicating to it its velocity. The principle would be like that employed for ventilation when air is carried in a long conduit by injecting a jet of air with great force into it. Experiment has shown that under these conditions, in the same section of the injector tube, the suction is stronger if the jet is spread in a thin sheet than if it is of a cylindrical form. The explanation of this is that in the first case the surface for friction is more extended. It has also been noted that the suction of the air is more intense when the injection is intermitted than when it is continuous. Now these two conditons, flattening of the stratum of air in motion and intermittence of the jet, are combined in the movement of the air, which flows at a tangent to the plane of a bird's wing. Finally, if a thin layer of air escapes from the back edge of the wing, and parallel to the plane of it, a reaction also parallel to this plane will be produced along the front edge, where the bony portions in relief prevent the air from escaping. It is this reaction which makes the bird advance. To demonstrate the reality of these phenomena, M. Muller has arranged little contrivances, by which loosening of a spring gave to a wing or a flexible plane a fluttering on a small scale. He then studied the movements, which were produced in the air (by making this visible) in daylight by means of smoke, following Tyndall's example, or at night by phosphorescent vapors. The existence of the compressed sheet of air escaping along the thin edge of the wing was revealed to him by the following experiment. In front of this flexible edge a thread of cotton is burned, which sends up a thin vertical column of smoke into the quiet air. The plane is lowered, a transparent aperture is produced in the column of smoke by the layer of air which escapes under the wing. This stratum draws after it, at right angles with its original direction, the column of smoke, which continues to form under it. The layer of air which escapes, following the plane of the wing, is scarcely ten millimeters or fifteen millimeters thick. The faster the motion, moreover, the thicker the air is. This current, on penetrating the motionless air, encounters resistance and produces whirls, which increase in size in proportion to the distance from their source, the edge of the wing. They attained in the experience of the author a decimeter in diameter. These whirls, which form one after another on both sides of the current of air, have an opposite rotation on the two sides. To render them visible, the author let the smoke or phosphorescent vapors accumulate under the wing, which he suddenly lowered, seeing then the two series of whirls form, grow, and multiply, speeding off and turning in opposite directions on the two sides of a plane in continuation of the wing surface. Finally, to show that a projection on the edge of the moving plane holds back the air and prevents its escape, he made use of a simple fan of folded paper, and after having proved that a certain rapidity of fanning produces a draught, he edged the fan with a narrow band of paper at right angles with its surface. By influence of this slight projection, which holds back the air, the breeze is stopped. To recall it, more rapid movement must be given to the fan. The layer of compressed air is then increased in volume, and escapes over the barrier.—*Comptes Rendus*, 103, 1886; *C., Jour. Fr. Inst.*

THE PERMANENT AND TEMPORARY EFFECTS PRODUCED BY RAISING THE TEMPERATURE OF IRON.

THIS was a paper by Mr. Herbert Tomlinson, B.A., lately read before the Physical Society, London. The paper is divided into three sections: (1) internal friction of iron; (2) the longitudinal and torsional elasticities of iron; and (3) the velocity of sound in iron. In his experiments on the internal friction of metals, the author uses a vertically suspended wire rigidly clamped at its upper extremity, and having its lower end secured to a horizontal bar of metal, attached to which are two cylinders of equal mass and dimensions placed at equal distances from the wire. When the system is set in torsional oscillation the amplitude gradually diminishes, due to the internal friction of the metal and the friction of the air. The combined effect is measured by the logarithmic decrement of the oscillations, and the air effect eliminated by Prof. Stokes' formulæ, and the author's experimental determination of the viscosity of air. When the deformations are sufficiently small, the experiments prove that the logarithmic decrement of arc is independent of the amplitude and period of vibration. These results are only true when the wire has been allowed to rest a considerable time after any change has been made in the arrangement, and when there has been a large number of oscillations executed previous to the actual testing. Reference is made to some experiments by Professor G. Wiedemann, which show that when a wire is subjected to torsional stress, it does not recover itself when the stress is gradually reduced to zero, but remains permanently twisted through a small angle—say θ. By reversing the twisting couple there a permanent set on the other side of the initial position. If the operations be repeated, θ diminishes and attains a minimum. The period during which this diminution takes place is called the "accommodation period." When a wire is in torsional vibration, the position of equilibrium is continually shifting to and fro, through twice the above minimum angle, and Wiedemann considers the loss of energy due to this shifting. The author's experiments verify Wiedemann's results, and also show that time and temperature have great effect on the internal friction. By repeatedly heating to 100° Cent. and slowly cooling an annealed iron wire for six days, the logarithmic decrement due to internal friction was reduced to about one-eighth its original amount at the same temperature, and when the wire was maintained at 98° Cent., the decrement was reduced to one-thirtieth. The author considers the permanent diminution produced by heating and cooling to be mainly due to the slow shifting backward and forward of the molecules induced by that process. In the second part of the paper it is shown that the effects of change of temperature on the longitudinal and torsional elasticities of iron and steel are not nearly so great as that produced on the internal friction. Thus by heating annealed iron wire, its longitudinal and torsional elasticities are slightly decreased; but on cooling, there is a permanent increase in both. Time is also an important element, for a long rest after cooling still further increases both elasticities. From the above results it is evident that the velocity of sound in iron and steel must diminish with rise of temperature. This was experimentally proved before the meeting. Attention was particularly directed to this fact, because most of the best text-books make the opposite and erroneous statement.

RAILROADS IN NEW REGIONS.*

WE shall now proceed to an analysis of the communication of Mr. J. R. Mosse. As we stated at the close of our former article, this communication has a more general character than that of Mr. Gordon. It treats especially of the principals to be observed in the study of the projects and in the construction and operating of the lines.

In regions that are but slightly developed, the railroads offer the following points of contrast with those of countries that have an advanced civilization. In England and other parts of Europe, railroads have generally been established as private commercial enterprises. In new countries, on the contrary, the state often undertakes their construction, either totally or in part.

Each of these systems naturally has its advantages and its drawbacks. The intervention of the state, which would be very prejudicial in England, is indispensable in new colonies that have little capital at their disposal, and where public works, which cannot be expected to yield any profit at the outset are yet necessary for the development and prosperity of the country. In other words, if we desire to undertake extensive public works, it is absolutely necessary that the latter shall be subsidized by the government. In Mr. Mosse's opinion, they will in this case be established under better conditions of construction, and be operated more advantageously for the interests of the public, than they would be by a private corporation. In the first case, it is rapid colonization and the general welfare of the country that is had in view, while in the second it is the profit of the stockholders.

In England, railroads have been constructed in measure as the population and commerce needed them. For example, from Liverpool to Manchester, then to Birmingham, and finally to London. In North America and Australia, on the contrary, railroads have been conceived upon a much vaster scale, not so much to create facilities for an existing commerce, as to encourage an increase of the population and the industries. For example, let us take the principal lines of the South and West in the United States; the line from Mobile to Chicago, 710 miles in length, the three Pacific lines, then in Canada the inter-colonial line from Quebec to Halifax, 660 miles in length, the Grand Trunk line, 640 miles in length, and the Canadian Pacific, from Montreal to Port Moody, 2,664 miles in length. This last named line, which was constructed especially with a view of opening up the far west of Canada, merits special mention. The company that undertook the work received a subsidy of twenty-five million dollars and a concession of 25,000,000 acres of land on the part of the Canadian government. This land consists of a strip 16 miles in width on each side of the road, and

* Continued from SUPPLEMENT, No. 587, page 9373.

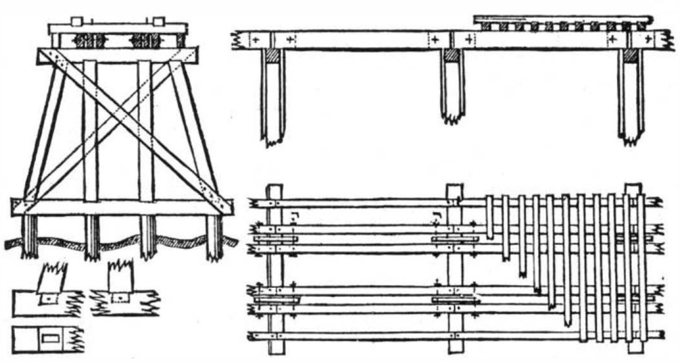


FIG. 12.—PILE WORK, CHICAGO AND ST. PAUL R.R. (Scale, 1-200.)

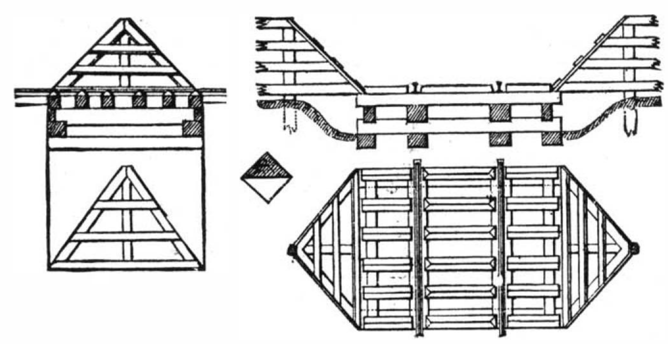


FIG. 13.—TYPICAL FENCES. (Scale, 3-400.)

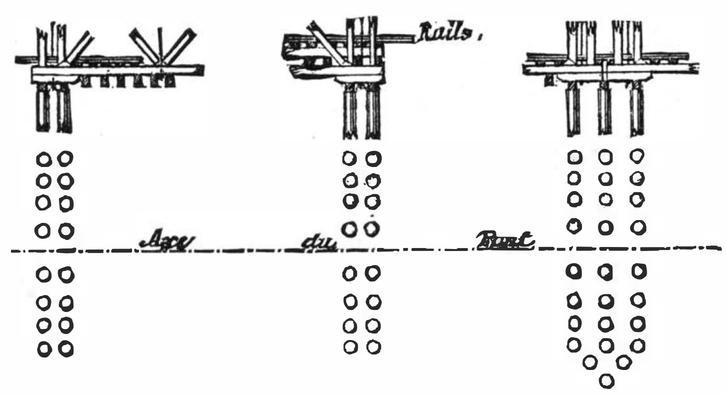


FIG. 14.—PLAN OF PILE WORK.

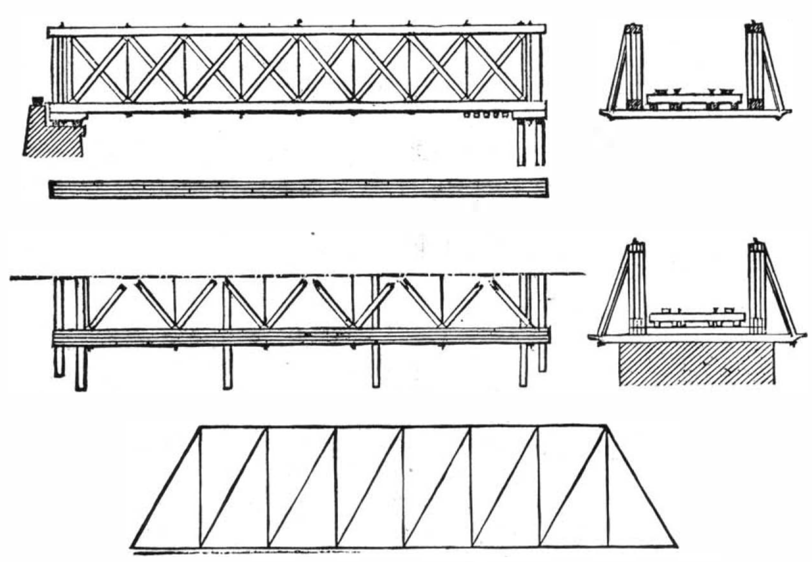


FIG. 15.—BRIDGE OF 65 FOOT SPAN. (Scale, 1-300.)

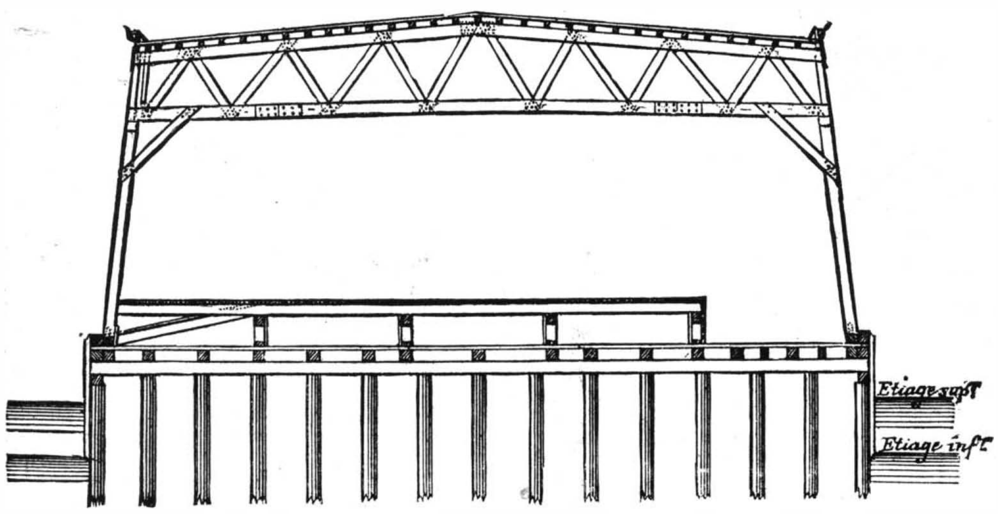


FIG. 16.—CROSS SECTION OF A CAR SHED. (Scale, 1-200.)

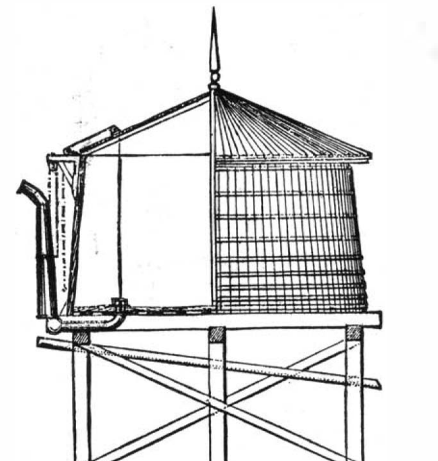


FIG. 18.—RESERVOIR. (Scale, 7-1080.)

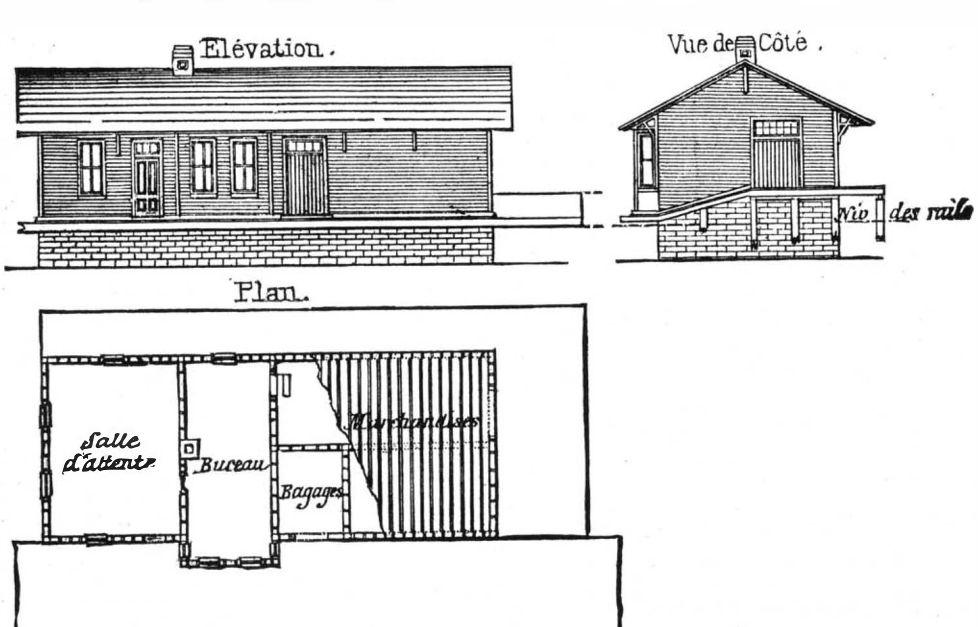


FIG. 17.—STATION BUILDING, CHICAGO AND ST. PAUL R.R. (Scale, 1-300.)

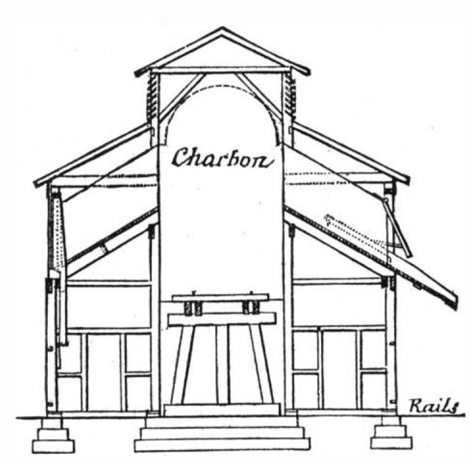


FIG. 19.—COAL HOUSE. (Scale, 1-200.)

WORKSHOPS, STATIONS, BRIDGES, ETC., OF AMERICAN RAILROADS.

is divided into portions belonging alternately to the government and to the company. Concessions of 160 acres are made to every individual who desires to settle on and cultivate the land. Canada will doubtless, ere long, derive a profit from this liberal policy. It is according to similar principles that the great lines of Australia, India, and of various colonies have been established. The locomotive, on its introduction, therefore, becomes rather the pioneer of civilization than an instrument of transportation.

The different conditions that we observe in a newly developed region naturally bring about very marked effects of contrast in the nature of the work. The needs of such a region are much fewer, and this necessitates fewer auxiliary constructions. On another hand, the geography of the country, the great mountains and the great rivers to be crossed, as in Canada and India, often necessitate very large bridges, and much larger ones than those that we find in England, for example.

Nature of the Lines.—In a level country, and where there is a limited population, it will usually suffice to have very light lines a first, and afterward to establish them in a more permanent manner. In mountainous countries, on the contrary, where an important traffic is anticipated, the heavier locomotives necessitate a more permanent road and stronger bridges. Upon the whole, the study of the line will have to serve as a guide for the construction of the various sections.

The Direction Line.—As for the laying out of the line, that will be regulated especially by the profile of the land. The road should be as direct and as level as possible. The operation of laying out the line becomes difficult where dense forests are to be traversed. When the ground is not too thickly wooded, we may reckon about one and a quarter mile per day for a provisional direction line, on taking the altitudes, and longitudinal and transverse profiles by one hundred feet at a time.

Gradients.—It often happens that a point to be reached, situated at a maximum altitude, regulates the direction line without there being much possibility of departing from it. We find examples of this on the Central line, on Mauritius Island, which rises 180.400 feet in 15 miles, with a few intermediate gradients of 1 in 27, and in the Nana-Oya line, in Ceylon, where the gradient, except in rare cases, is 1 in 44 over a stretch of 18 miles. On another portion of the same line, the gradient is 1 in 44 in a stretch of 9 miles. In such cases, the direction line should submit to the exigencies of the road, and it is useless to seek a route that will permit of a minimum of excavating and filling in.

Moreover, the maximum gradient to be observed depends especially, for ordinary locomotives, upon the nature of the country, upon the capital designed for the construction, upon the extent of the traffic, and upon the speed required.

Mr. Mosse was superintendent of the Mauritius Island railroads for five years, and, having had experience with their steep gradients, deduces the conclusion that a gradient in excess of 1 in 40 should be avoided whenever it is possible. When it is necessary to adopt a gradient of 5 feet for a certain number of miles, it is preferable in many cases to adopt a gradient of 1 in 45, and to convert the approaches to the stations into horizontal tracts between the inclines. This permits of stopping a train or uncoupled cars, and gives the enginemen and conductors more confidence.

Curves.—Despite the advantage that is found in adopting gentle curves, it becomes in most cases impossible in mountainous countries, and it is therefore necessary to study the minimum curve that is compatible with security and the wear of the track and rolling stock. On American 4½ foot roads, there are curves of from 325 to 390 feet radius, over which run cars carried by four or six wheeled bogies, hauled by locomotives having a base of from 60 to 65 feet, with bogies in front. American locomotives have more play and roll more easily on curves than English ones do. The curves are often still more pronounced in Canada, as well as in Ceylon, where, over several miles, they are found on gradients of 1 in 44.

Gauge.—The question of the spacing of the rails or the width of the track has often been discussed. In Mr. Mosse's opinion, the gauge ought not to be less than 4 feet nor greater than 5 (the gauge of the Irish railroads). As a medium, 4½ feet has been almost everywhere adopted.

Construction.—Whatever be the nature of the line, the necessities of the future should be looked after. For the sake of a saving in the expenses of the first establishment, as well as for facilitating the operation of the road, the work should be executed in a substantial and irreproachable manner. There is nothing more costly than the additions that become necessary as a consequence of inadequate work, or than the modifications that have to be made because of a too slighted execution or the use of too cheap materials.

Excavation and Filling In.—These are matters that depend especially upon climate, rains, and nature of the earth. On the Canadian Inter-colonial Railroad, for example, the cuttings have a width of 30 feet at the base, with drains 4 feet in depth at the sides, while in a milder climate a width of 20 feet would suffice for a single track. The inclination of the earth may likewise be much greater in temperate climates than where the heavy frosts of winter cause the earth to give way in gradients of 4 to 1 only.

Everywhere where land is cheap it is more economical to use excavated material for filling in, and to take this from side cuttings rather than to have to transport it in cars. This, moreover, is the nearly general practice in the United States and Canada.

On some of the United States lines, the contractors were generally paid by the cubic foot of excavation and filling, while at the same time they were free to use the earth removed or to take it from side cuttings. This is the custom in India also.

Management of Water.—The precautions to be taken against inundations form one of the most essential studies in establishing a railroad line. In the first place, it is necessary to become well informed as to the levels of the overflowing waters in the region, as to the rains, as to the general configuration of the land, and as to the maximum daily fall of water during the rainy season.

In England, rains of 3 inches per day are quite exceptional, but in the tropics a fall of 10 and sometimes 18 inches per day is to be expected. This is why it is always necessary to preserve a considerable margin for the flow of the water. Mr. Mosse advises, as regards bridges, a height of 5 feet above the highest inundation level, with proportionally wide waterways.

Bridges.—The direction line is often determined by selection of a suitable spot for crossing a large water course. It is especially necessary to adhere to good foundations, and to seek moderate depths. In such countries as India or America, it is necessary to use the means employed in the country for foundations. In India, for example, the foundations will consist of brick cylinders sunk in the bed of the river, while in America, on the contrary, where wood is abundant, they will be constructed upon piles and planking, to the exclusion of caissons and beton.

Everywhere where stone cannot be obtained near the work, it will be first necessary to build a wooden bridge lasting but about a dozen years, but which will permit of constructing a stone or iron bridge at leisure. Such bridges will have to be as light and as cheap as possible, and Mr. Mosse recommends as a type of girders those of the Howe system. For iron bridges, it seems preferable to him to adopt pieces connected by pins, as in the Warren girder, on account of the difficulty and bad quality of the riveting in these countries.

Masonry.—The masonry should generally consist of dressed stone of small size or of ordinary flat ashlar.

In the tropics, it is difficult to obtain stones damp and cold enough to be put in place. They are generally of a temperature that greatly interferes with the

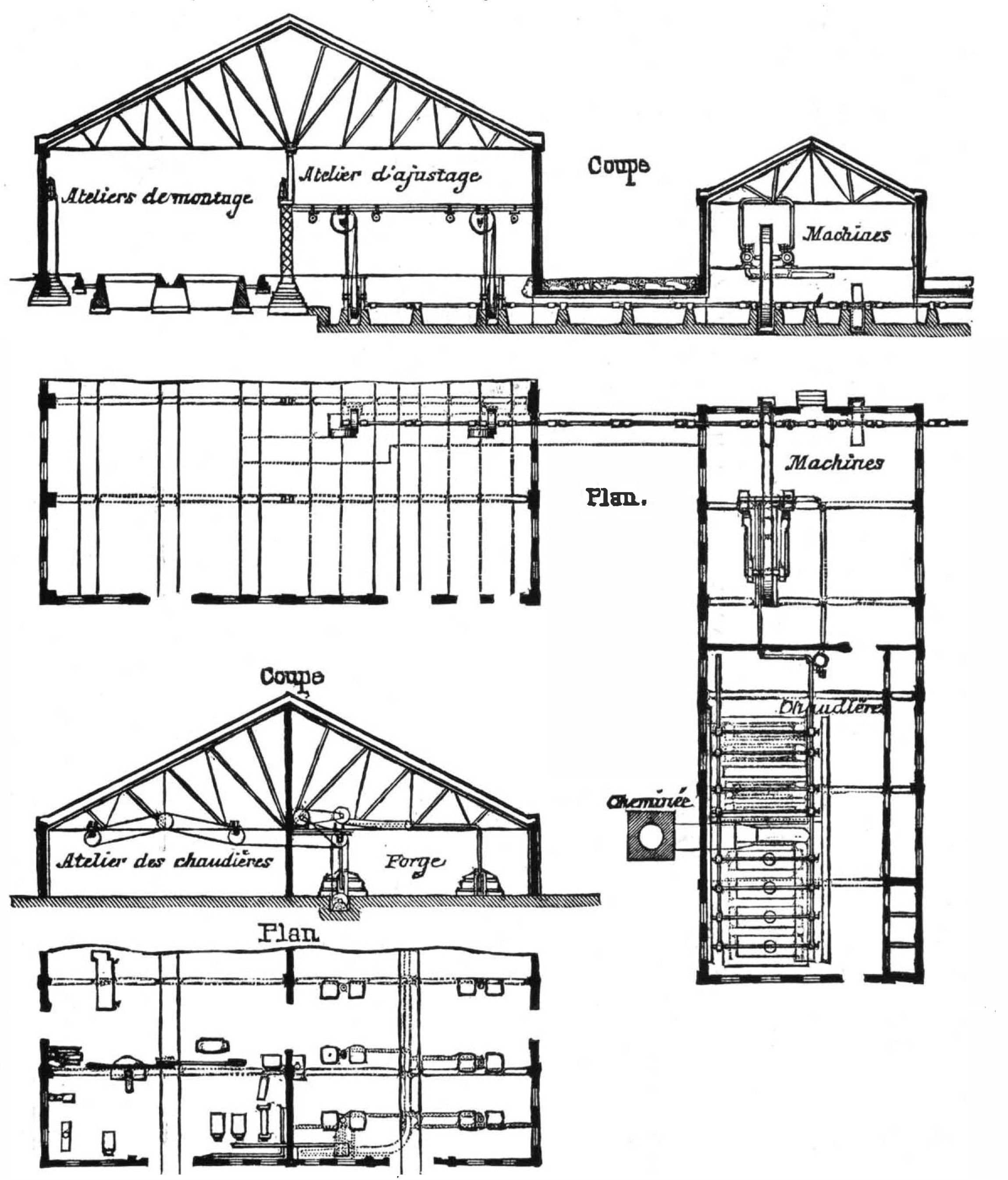


FIG. 21.—DETAILS OF WORKSHOPS AT BURLINGTON, CANADA.

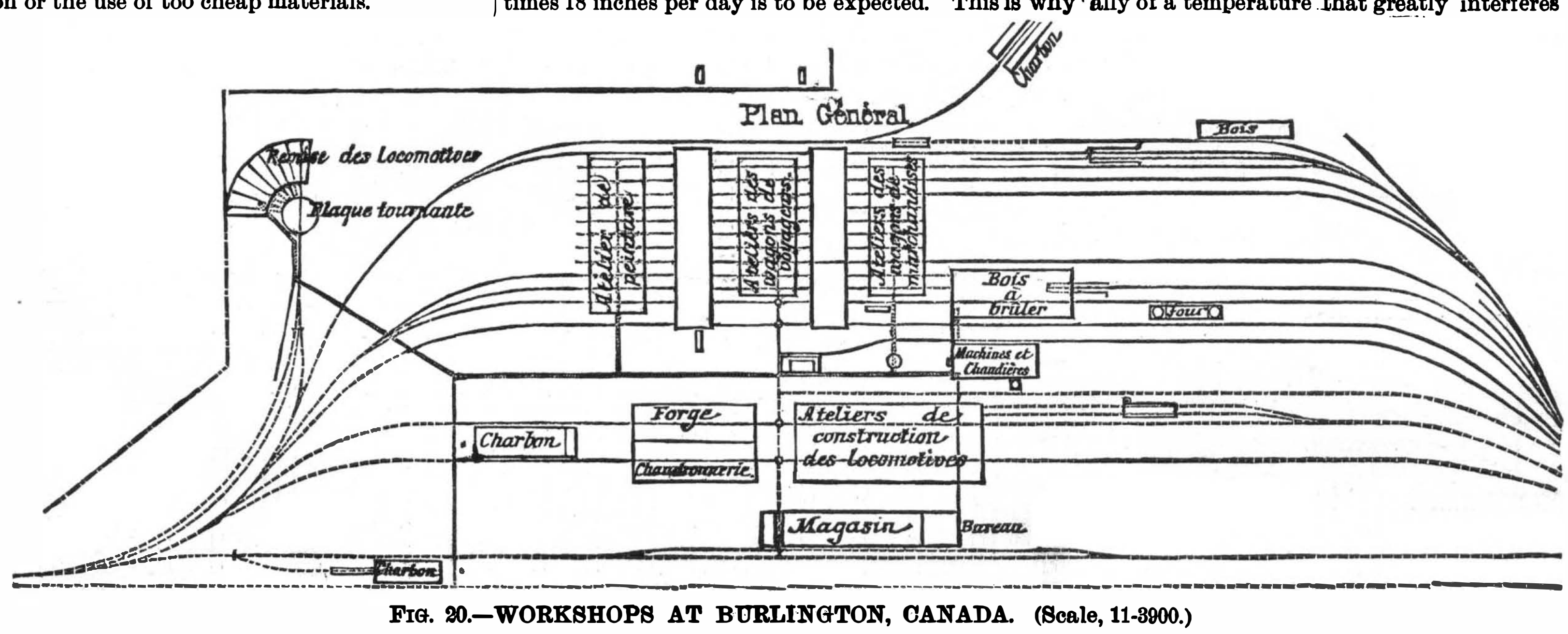


FIG. 20.—WORKSHOPS AT BURLINGTON, CANADA. (Scale, 11-3900.)

WORKSHOPS, STATIONS, BRIDGES, ETC., OF AMERICAN RAILROADS.

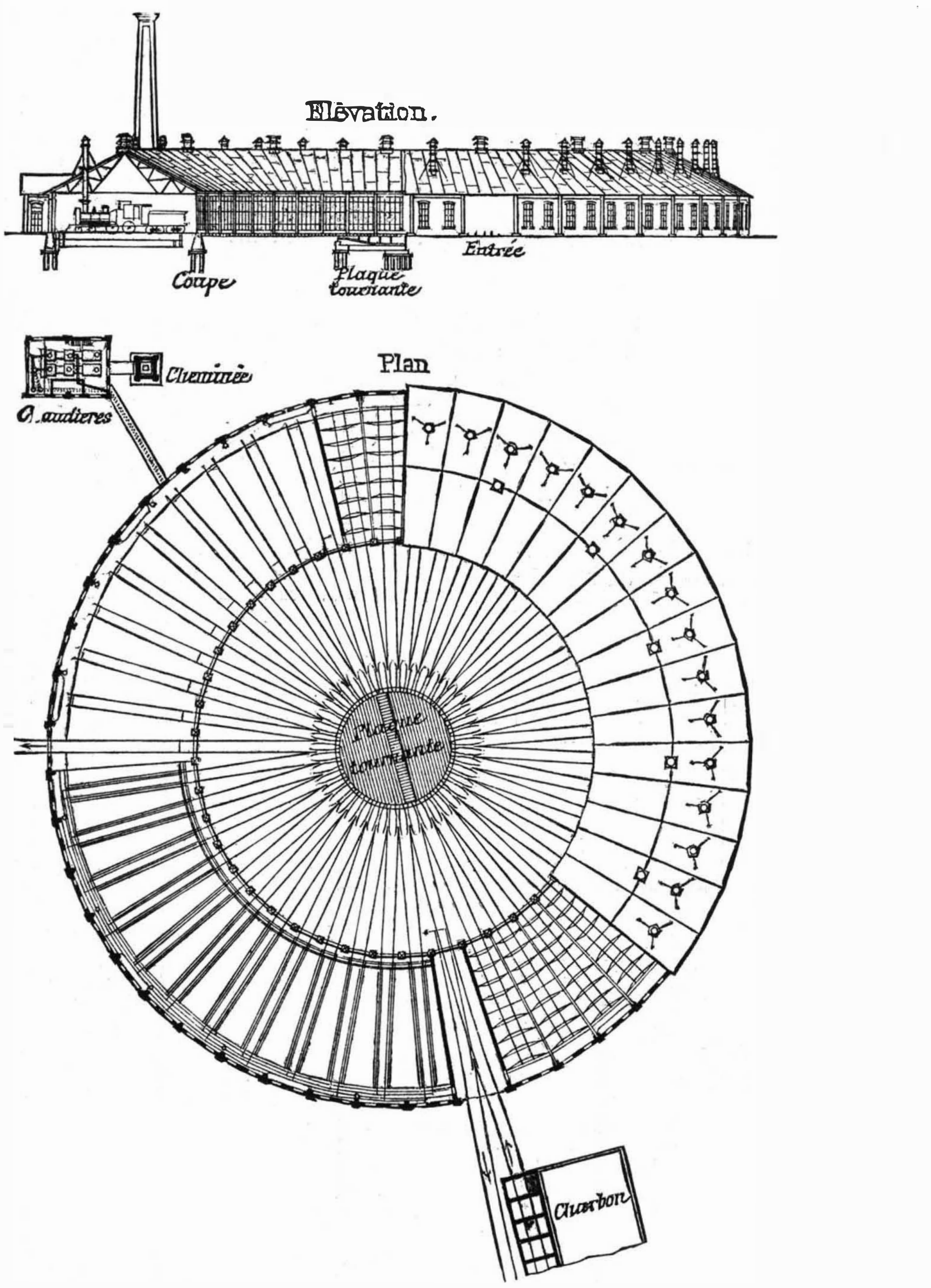


FIG. 22.—LOCOMOTIVE HOUSE AT MILWAUKEE. (Scale, 1-930.)

setting of the mortar. It is for this reason also that the beton should there be mixed with more water than it is in temperate climates.

The Track.—The rails will be from 14 to 24 pounds per running foot, with fish plates, bolts, dimensions of ties, and depths of ballast corresponding to the rail employed. As a general thing, a rail weighing less than 19 pounds to the running foot should be discarded. In new regions, it will be preferable to use a Vignoles rail about 19 feet in length. This type is more easily laid, and requires fewer accessory pieces, thus facilitating carriage. Each rail should be supported by at least seven ties. Guard rails should be laid along all curves of less than 600 feet radius. On account of the severe frosts in very cold climates, and on account of the abundance of rain in the tropics, the lower ballast should consist exclusively of small broken pebbles to a depth of 8 inches, and the upper stratum, 12 inches in thickness, should be of very good gravel. The ballast should cover the ties, so as to protect them against the heat of the sun. A well laid track is always more economical in the end than a cheaply constructed one. In Canada, as in India, the green wood ties of the country last but a short time, and it is preferable to import creosoted fir-wood ties from the Baltic.

Stations.—Whatever be the size given the station buildings at first, they almost always have to be enlarged in the future. The necessary land should therefore be reserved for subsequent structures. For a single track line in a new region, Mr. Mosse recommends two shunts, one on each side of the main track, in order to permit of the passage of three trains. The station platforms for passengers should be about 290 feet in length, since the trains, being spaced, are often very long. The freight houses and shunts should be so located as not to interfere with the running of passenger trains.

Rolling Stock.—The rolling stock depends upon the nature of the line and the extent of the traffic. The steeper the gradients or the larger the traffic, the more numerous and powerful will the locomotives be. It is wise economy not to strain the rolling stock, and especially the engines. In order to meet the expense of repairs and such exigencies as may arise, it will require a margin of about 25 per cent. With the exception of Canada and Australia, which manufacture their own locomotives and the iron work of their cars, the English colonies usually import their rolling stock from the mother country. The carpenter work is very well done in the colonies, and is of pitch pine in America, and of teak in India and other countries of the East. The locomotives of the Ceylon railways, which run over gradients of 1 in 44 and curves of 300 feet radius, weigh $45\frac{1}{2}$ tons. They were built by Messrs. Kitson & Co.

Upon the lines of Mauritius Island, with gradients of 1 in 27 and 1 in 40, the locomotives are of two types, the first one of which has six coupled wheels and weighs 37 tons with water and coal, and the second has eight coupled wheels and weighs 48 tons.

The following is the proportion of the locomotives and cars upon the lines of North America:

Miles operated	133,126
Number of locomotives	27,958
" passenger cars	33,662
" freight "	831,163

The proportion, then, is as follows: locomotives, 1;

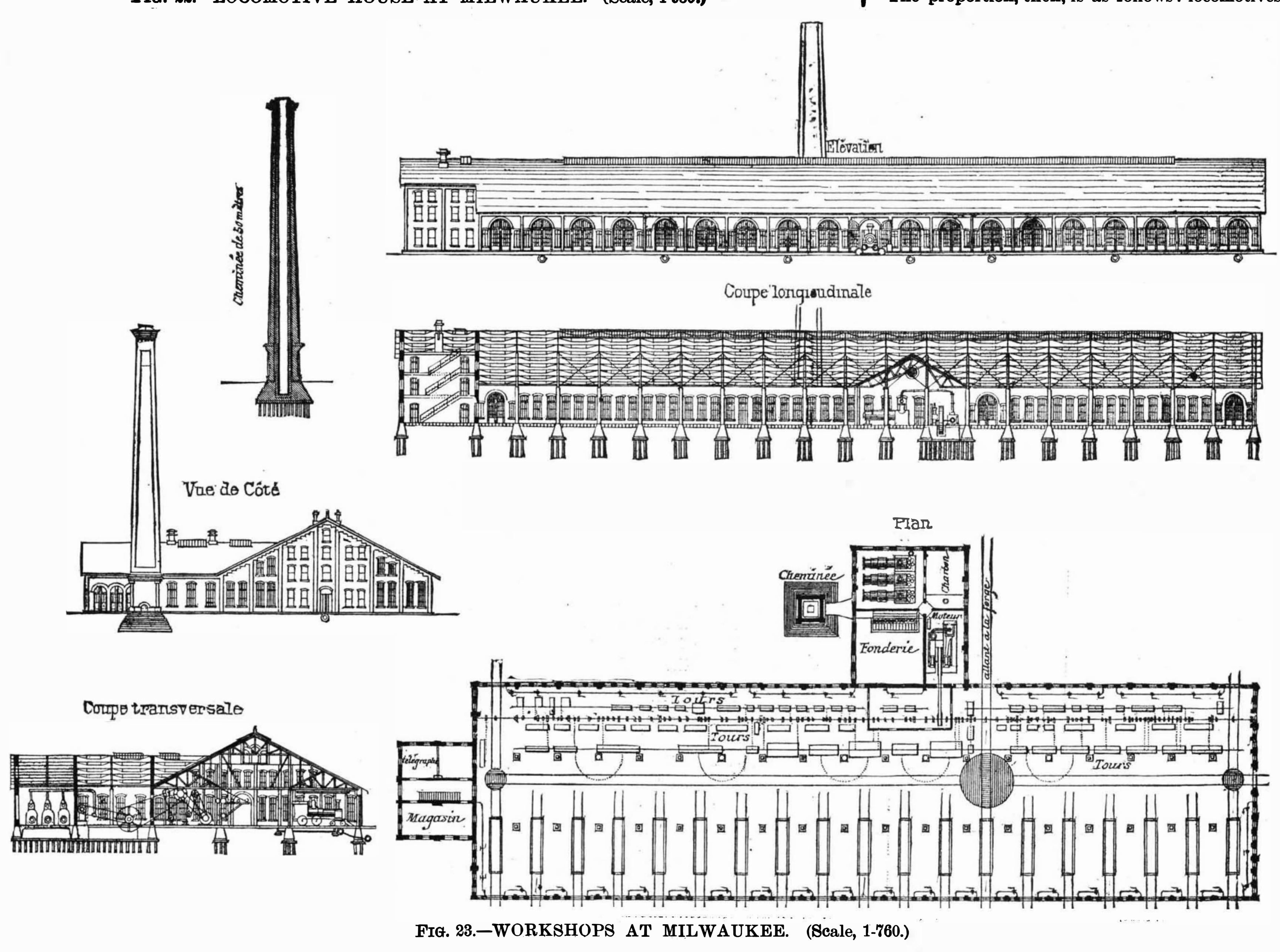


FIG. 23.—WORKSHOPS AT MILWAUKEE. (Scale, 1-760.)

WORKSHOPS, STATIONS, BRIDGES, ETC., OF AMERICAN RAILROADS.

passenger cars, 1·2824; and freight cars, 29·739. These figures will show how much more important the carriage of freight is than that of passengers, in new regions.

We now pass to Mr. Cunningham's communication upon the Canadian Pacific Railroad. This paper, which is necessarily of a more special nature, and which we have several times alluded to in this article, we shall briefly summarize: The land traversed by this line belongs to the lower carboniferous system. In it are found many hard and crystalline limonites (which sometimes closely resemble marble), as well as schists of various natures, from very hard, dark slates up to softish clays that have undergone a preliminary lamination.

Climate.—The climate over a great portion of the route, on account of the latitude and elevation, is generally very cold, and snow does not disappear till the end of June. Upon the eastern and western declivities, however, the temperature is less rigorous, and approaches that of Central Europe.

Building wood is met with in abundance, but the moss that covers the earth does not permit pasture grass to grow, and it cost a good deal of money to transport forage for the beasts of burden employed in the work.

Construction of the Road.—Before beginning the line, it was first necessary to construct a wagon road for carrying the contractors' equipments, materials for the road, provisions, forage, etc., so that the work might be started at a large number of points simultaneously. The contracts varied in importance from 960 down to 5 miles of roadway. When one section was finished, the contractor at once went forward, so that there was always at least 36 miles between the most advanced point and that at which the tracks were being laid. The wagon road rendered the greatest services, and, although the elements and the loads carried often put it in a very bad state, this inconvenience was of slight importance, since it was used only during the construction of the section that it skirted.

The curves and gradients were made as gentle as possible as far as to the Rocky Mountains, where, in order that it might be sooner finished, the line had to be given a less permanent character, and the curves and gradients to be made more pronounced, it being left for future modifications of the direction line to reduce them.

The total length of the tunnels is 72 miles. They are generally 21 feet in height at the key, and 14¾ in width. They are lined with timber wherever they pass through argillaceous earth or through gravel.

The bridges are almost exclusively of wood obtained *in situ*. The nature of the defiles to be traversed in the Rocky Mountains considerably increased their number.

The line is a single track one, with Sandberg steel rails and angle iron fish-plates. The rails weigh about 19 pounds to the running foot in the level portions, and 20 where the curves and gradients are very pronounced. The ties are 8 feet in length, 9 inches in thickness, and 9 inches in width. The distance from center to center of the ties is 30 inches. The latter are of wood cut on the mountains, and are of larch and spruce.

The work required a large amount of dynamite, which had to be manufactured at a locality on the line on account of the high freight charges on this substance and of its dangerous nature.

Mr. Cunningham concludes his report with a review of the rolling stock employed on the line, and which has much analogy with that which we have already described.—*Annales Industrielles.*

IMPROVED METHODS OF HEATING RAILWAY TRAINS.

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

I.

THE AMOUNT OF HEAT REQUIRED FOR TRAINS OF VARYING LENGTHS.

So much confusion seems to prevail in the railroad world as to the quantity of heat required to maintain an equable temperature in a railway car during the winter months, that the writer has felt constrained to undertake a solution of the problem that will be a satisfactory criterion for future calculations.

In regard to the confusion of ideas existing upon this subject, it is well to place on record briefly what has been said by railroad men.

"Why," said a prominent railroad man, "to warm up such a train as the 6 P. M. St. Louis express, from New York to Chicago, we would need an eight inch steam pipe. The longer the train is, the bigger the pipe will have to be." In which there is some truth and a percentage of fiction.

On the other hand, we have read repeatedly the testimony of various engineers who declare "the amount of steam taken from the boiler is scarcely perceptible, and the required pressure of steam is maintained without any additional effort or apparent increase of the quantity of fuel used." In response to this testimony, Mr. Martin publicly replied: "I do not believe any of them have given a critical, careful weighing of coal and water that would supply the scientific data in the matter."

An official test of the steam heating apparatus (the Martin), as applied by the Milwaukee and St. Paul, was made upon that company's short line train, which runs between St. Paul and Milwaukee. The test seemed to be perfectly satisfactory, the thermometer registering 80° within the car, while outside it stood at zero, with a pressure of six pounds to the square inch inside the car. The heat was distributed equitably, and seemed to be devoid of the dryness which is ordinarily experienced in day coaches when heated by stoves. The fireman of the engine declared after the test that he saw no perceptible difference in the amount of coal used.

Again, one prominent engineer declares that 1,700 pounds of water evaporated into steam would be required to heat a train of seventeen cars, or 100 pounds per car. In the test just alluded to on the St. Paul road, tanks were provided to retain all of the condensed steam, and the amount was reported to be 8½ gallons per hour, or equal to nearly 71 pounds of distilled water, and even this must be regarded as a high estimate, because the temperature of the five cars heated was maintained at 80° Fahr., which was 10° higher than necessary, and the pressure was also greater than necessary, which the calculations we have made will prove.

One brilliant writer in a Western paper declares that the device consists of the use of the *exhaust steam from the dome* of the engine, etc. This seems to be a reservoir of exhaust steam which would strike many an old engineer as peculiar.

One of the wiseacres of the technical press pronounces steam heating from the boiler wholly impracticable, and he says the locomotive cannot stand the drain of steam away from it. These declarations are solemnly uttered from various editorial sanctums, but the steam of misinformation has condensed into such a thick vapor upon their monocles that they have been unable even to see over its golden rims and read of the successful operation of steam heating on railways, which has now been thoroughly tried for more than three years. The problem that the steam heating inventor is confronted with may be resolved into a statement of the conditions and requirements.

1st. The temperature of the car must be maintained at 70° Fahr. even when the thermometer of the air outside registers zero.

2d. The air must be changed in a car four times an hour, in order to insure perfect ventilation.

3d. The heat must be so distributed that a uniform temperature can be maintained.

4th. The storage of heat sufficient to maintain the temperature at its normal state for three or four hours.

Some practical objections have been raised in regard to steam heating, for the reasons that cars cannot be heated before the locomotive is attached; and, secondly, that cars taken *en route* cannot be heated; and, thirdly, a train snowed in, or involved in a wreck, cannot be heated.

The first objection can be met by a provision at every terminal point or large stations for a simple system of supply piping from a stationary boiler, or by connection with some *idle switch engine* that is making steam without using it. Cars on trunk lines are very seldom taken on at unimportant way stations. The practice is to take them on at some prominent point, for instance, where engines are changed. At such points cars could be heated beforehand by the means suggested. Thirdly, trains stuck in a snow drift are not kept warm many hours by any kind of a heater, and it is an exigency which could be met by temporary fires in stoves in the cars acting as auxiliaries, but not such stoves as occasioned the fire at White River Junction.

THE PROBLEM STATED.

It is desired to know the amount of heat required to maintain a temperature of 70° Fahr. with the external air at 0° Fahr., and the air of the car to be completely changed four times an hour.

We desire to apply this problem to a standard passenger car of the most approved type of construction. Through the courtesy of Messrs. J. G. Brill & Co., of Philadelphia, we are able to make use in our calculations of what will be recognized everywhere as a standard American passenger car. The total outside dimensions are 60 feet 4 inches, with four inches between crown pieces when the cars are coupled together.

The interior length of the car, from door face to door face, is 50 feet 9 inches. The width on the floor, from wall face to wall face, is 8 feet 8½ inches. The height, from under side of deck to top of floor lining, is 9 feet 5½ inches. The thickness of the side walls is 6 inches, and this thickness is to be regarded as a solid mass of pine wood, through which the heat rays are supposed to pass at right angles to the fibers. The thickness of the floor and ceiling are each assumed at three inches, with the heat rays at right angles to the fibers.

With these dimensions, making no allowance for ogee curve of the roof, regarding the excess of space so provided for as a factor of safety, the cubic contents of the car amount to 4,180 cubic feet. The windows are to be classified by arranging them in three divisions. First, the side windows, seventeen on a side and two at one end and one at the other end of the car, making thirty-seven windows whose glass area, 22 × 30 inches, would amount in all to 170 sq. ft. Second, the deck windows, 22 × 5½ inches, and thirty-four of them; their glass area is 26 sq. ft. And thirdly, the door windows, containing 4 sq. ft. Total glass area then is 200 sq. ft.

Now, the plan of procedure is to first suppose the air is constantly maintained at 70° within the car, to find out how many units of heat are emitted through or absorbed by the walls, the windows, the floors, and the ceilings of the car, and finally how many units of heat are absorbed or consumed in raising the temperature of the incoming air from 0° to 70° Fahr. four times an hour.

Then, taking the sum of all the units thus ascertained, and calculating the amount of 2 inch pipe and also 1¼ inch pipe it would require to supply such an amount of heat with the maximum pressure of the steam at 5 lb. per square inch, and also to find what the amount of condensation is per hour, the number of pounds of steam required per hour, so as to learn what the drain would be on the engine having an effective horse power of 500.

AMOUNT OF HEAT ABSORBED BY WALLS.

The heat absorbed from a body by contact with cold air is not influenced by the nature of the surface, all materials losing the same amount under similar conditions of temperature, nor does the form of the body affect the result materially, as was formerly supposed. The loss varies only with the more or less disturbed condition of the air in contact, which in this case is expressed by the factor 5, as the air is constantly renewed.

We have used the formula $L = 0{\cdot}09824\, y\, (t - T)^{1{\cdot}233}$ for obtaining the loss of heat by air contact. We will apply the formula first to obtain the heat-absorbing value of one square foot of surface on the side of the car. In this formula, L = loss of heat by contact per square foot per hour; t equal the temperature of the steam within the pipes; T equal the average temperature of the air within the car; $y = 5$ for moving air.

According to the best authorities, the temperature of dry steam under 5 lb. pressure per square inch is 228° Fahr. In this calculation we will assume that 5 lb. pressure is the maximum, and we would set the steam valve beneath the car to discharge steam at any greater pressure.

Then $L = 0{\cdot}09824 \times 5\ (228 - 70)^{1{\cdot}233} = 252{\cdot}46$ units lost for a difference of 1°. Now to find the total heat lost we must multiply the difference between the temperature of the air within the car and that of the internal surface of the car walls by this loss for 1° difference of temperature. The temperature of the air within the car we are to establish at 70° Fahr., but the temperature, $t\,x$, of the interior surface of the side wall of the car we do not know, but must calculate it from the conditions we have imposed.

The value of $t\,x$ can be obtained from the formula:

$$t\,x = \frac{Q\,(ELT + CT_1) + LCT}{C\,(2L + R) + ELQ}$$

and the notation is Q = R + L. R = radiating power of the wall, L = loss of heat by contact per square foot per hour, E = thickness of wall in inches, T = temperature of the air within the car, C = the conducting power of the wall. Then, according to our conditions, E will be 6 inches, R = the radiating power of pine wood across the fibers in units of heat per square foot of surface for a difference of one degree, or 0·7358; L = 252·46; T = 70° Fahr.; C = 0·748; T_1 = 0° Fahr.; Q = R + L = 253·2. Then we will have

$$t\,x = \frac{253{\cdot}2(6\times252{\cdot}46\times70)+(252{\cdot}46\times{\cdot}748\times70)}{{\cdot}748\times2\times252{\cdot}46+{\cdot}748\times{\cdot}7358+6\times252{\cdot}46\times253{\cdot}2} = 69{\cdot}965$$

Then $U = l\,(T - t) = 252{\cdot}46\,(70 - 69{\cdot}965) = 8{\cdot}836$ units of heat lost or absorbed per square foot of surface for the given thickness per hour.

FLOORS AND CEILINGS.

Having carefully worked this formula through, and also those of Prof. Box, which give nearly the same results, the conclusion has been reached that the rapidity of the cooling of surfaces is inversely proportional to their thicknesses; thus, of two walls, one having a thickness of 4 inches and the other of 2 inches, the second or thinner wall will cool off twice as rapidly as the first wall.

We can make use of this principle in calculating the amount of heat absorbed by the floors and ceilings. They have been found by measurement to be 3 inches thick; a square foot of floor or ceiling in this case will then absorb twice as many heat units as the side walls. This amounts to 17·672 units per sq. ft. per hour of surface of floors and ceilings.

THE WINDOWS.

To determine the loss through the windows, we shall use the formulas deduced by Thomas Box. We start out with the supposition that the glass walls of the car or rather its glass surface is exposed on all sides, the internal air at 70° Fahr., external air at 0° Fahr. We must first find the temperature of the glass. If we multiply the temperature of the air within the car by the loss of heat in units per square foot per hour for 1° difference in temperature by a vertical plane, and divide this amount by twice this factor plus the radiating power of our material, we shall then have the temperature of the glass. Thus:

$$ty = \frac{0{\cdot}5121\times70}{(2\times0{\cdot}5121)+0{\cdot}5948} = 22{\cdot}14^\circ\ \text{Fahr.},$$

and $U = Q\times(T - ty)$. Q = 1·1069. Hence U = 52·976 units of heat absorbed per hour per square foot of glass area.

As we have 200 feet of glass area to account for, we shall lose by its absorption 200×52·976, or 10,595·2 units of heat.

The areas of the side and end walls amount to 924·748 square feet. Hence 924·748×8·836 units = 8,171 units per hour. The areas of the floor and ceiling amount to 883·89 square feet, and 17·672 units of heat per square foot are required per hour. Hence 883·89×17·672 = 15,621·4 units of heat per hour. Thus the total amount of heat absorbed by the floors, the ceiling, the walls, and the windows is 34,387·6 units of heat per hour.

The cubic contents of the car itself is 4,180 cubic feet; but, as the air is to be changed four times an hour, we are obliged to heat four times this quantity, or 16,720 cubic feet of air per hour, or about 239 cubic feet of air per capita.

THE AMOUNT OF HEAT REQUIRED FOR THE AIR IN THE CAR.

The units of heat necessary to warm the fresh air can be obtained from the formula $U = Qnws(T - T_1)$, in which Q is the cubic contents of the car in feet; n the number of times that Q is to be renewed per hour, w the weight of air at 0° Fahr., s the specific heat of air, T is 70° Fahr. and T_1 is 0° Fahr. Hence Q = 4,180×4×0·0864×0·238×70=24,067·16 units of heat required to heat the air in the car—the incoming air at 0° Fahr. renewed four times an hour, and the temperature of the air within the car maintained at 70° Fahr. The total amount of heat required per hour per car, expressed in units of heat, is, so far as calculated, say 58,455 units. We have still to calculate the loss by convection or the amount carried away by the moving air surrounding the train; or we may consider the train to stand still and conceive the air to be rushing by it with the actual velocity of the train. This loss will not be so great as might be expected, owing to the non-conducting character of the woodwork of the train. We have made an allowance with a factor of five, which is equivalent to a loss one and two-thirds greater than would occur in quiet air. Under the head of the "Loss of Heat Due to Impact of Cold Air," we have shown the increment of loss in heat units by convection of the main supply pipe to be 2,800 units of heat. We have estimated the additional loss by convection to strong winds to be, on the average, the same amount per car per hour.

THE AMOUNT OF PIPING REQUIRED.

We now desire to know the amount of piping that will be required to convey this heat and emit it. We know, by previous calculation, that 252·46 units of heat are lost per square foot for 1° difference by contact. By the formula $L_1 = 225r(1{\cdot}0043^{t-32} - 1{\cdot}0043^{t_1-32})$ we are able to find the units lost per square foot by radiation. This amounts in our case to 145·43 units. Total emission by contact and radiation for one degree difference is 398 units per square foot. By dividing the total number of heat units required by the number of heat units

emitted per square foot of pipe, we shall find the amount of square feet of pipe required. This we find to be $\frac{64,055}{398}$ = 167 square feet of pipe. Expressing this in lengths of standard 1¼ inch pipe, we find it would require 382 feet of 1¼ inch pipe, or 267 feet of 2 inch pipe. How closely this latter figure approximates practical results will be seen when it is remembered that the steam heating company puts in 275 feet of 2 inch pipe to heat a car not so long as the standard car; but, on the other hand, not so well protected by non-conducting walls, floors, and ceilings, and with one pound more of pressure than our maximum.

THE AMOUNT OF STEAM CONDENSED PER HOUR PER CAR.

To obtain this amount, we divide the total units of heat consumed by the number of units of heat required to evaporate one pound of water under one atmosphere. The unit of evaporation is 966. Hence 64,055 ÷ 966 = 66·3 pounds of steam condensed to 212° per hour. This may be found again in another way. The above being the maximum, in practice the amount is found to be lower. Thus the mean result of several experiments with bare cast iron pipes, with steam at absolute pressure of 20 pounds pressure per square inch, the steam condensed per square foot is four-tenths of a pound. As this condensation is directly proportional to the radiating power of the vehicles of transmission, if we know this radiating power, we can compare their powers of condensation. Thus the radiating power of cast iron is 0·648, and of wrought iron 0·5662. Hence 0·648 : 0·4 :: 0·5662 : x. Hence x = 0·35 pound per square foot of surface. We have already shown that we have 167 square feet. Hence if this pipe were of cast iron, it would condense 66·8 pounds of steam per hour; and if of wrought iron, 58·45 pounds of steam.

These results are based upon the observed radiating effects in quiet air. For rapidly moving air, however, the loss by convection would augment the condensation by an amount not far from fifteen per cent. On this basis the condensation from the use of wrought iron pipes, with the surface we have exposed, would amount to about 67 lb. of steam condensed per car per hour, and this amount is not materially larger than that shown by a previous calculation. This last result, we believe, will coincide closely with the results of one season's accurate measurements. In our calculations we shall take as a basis 66·3 lb. of steam as the theoretical amount required.

THE AMOUNT OF COAL CONSUMED PER HOUR PER CAR.

There are two general methods of estimating this amount. One is by dividing the total number of thermal units (64,055) consumed by 7,000, the effective heating (average) power of one lb. of coal, by which process we obtain 9·15 lb. of coal per car per hour, or by dividing the amount of steam in lbs. consumed per hour per car by the average amount of water condensed per lb. of coal for 60 lb. of fuel per square foot of locomotive grate per hour. By experiment, this amount of water, condensed per lb. of coal, with these conditions, which are average, we obtain 66 3÷7=9·5 lb. of coal per car per hour. The average of these two results, or 9⅓ lb. of coal per car per hour, will represent a fair average referred to an ordinary locomotive.

In this vicinity, coal costs the railroad companies about three dollars per ton, or 1½c. per lb.; in Western Pennsylvania it costs them, say, $1.60 per ton or 0 008c. per lb., or on an average 0·0115c. per lb. throughout the country. This would bring the cost of heating a car per hour to about 10$\frac{6}{10}$ cents.

THE DRAIN ON THE LOCOMOTIVE

can be estimated in several ways. First by reference to the horse power consumed, and second by the lbs. of steam consumed per hour, and third by the square feet of heating surface required to produce the steam consumed.

The estimation by horse power, however, is quite unsatisfactory, as reputable engineers all over the world are unable to agree as to the value of a horse power. Conservative engineers place this theoretical value at 40 lb. of water evaporated per hour. At this rate it would require about 1·65 horse power per car per hour. Suppose the locomotive to be of 500 horse power, and the train one of fourteen cars, we should need 22·6 horse power, or 4$\frac{52}{100}$ per cent. of the locomotive's power. In regard to the value of a horse power, we would prefer the value obtained by using the results arrived at by the Judges at the late centennial exhibition, namely, as that of the equivalent of 30 lb. of water evaporated at 70 lb. pressure from 100° for each horse power. By reference, the temperature of steam under 70 lb. pressure is 316° Fahr. The latent heat of evaporation of steam at 212° from 0° is 966·1, and the total amount of heat necessary to raise one lb. of water from 0° to 316° is therefore 1282·1 units; but this one lb. of water is to be converted into steam from 100° Fahr. instead of zero, so we shall require one hundred units less, or 1182·1 units. To convert 30 lb. of water into steam at 70 lb. pressure from 100°, we shall therefore consume 35,463 units of heat per horse power; as we are to use 64,055 units, the horse power equivalent is therefore 1·8 horse power per car per hour. For a fourteen car train this would amount to 25 horse power, or a drain on a 500 horse power engine, which is a fair average power expended in hauling such a long train, would amount therefore to a drain of five per cent. on the power of the locomotive. The equivalent of this power may be represented in the heating surface. Thus, taking a standard first class passenger locomotive, such as those built by the Rogers locomotive works for the West Shore Railroad, having a grate area of 34 square feet, and a total heating surface of 1,212 square feet, the percentage of power expressed in heating surface would require about 60 square feet of heating surface, to heat a train of fourteen passenger cars such as we have described.

As one square foot of grate area requires about 56 square feet of heating surface, and as we should need 60 additional square feet of heating surface, we should need a little more than one additional square foot of grate area in order to make no perceptible drain on the present power of the locomotive for a fourteen car train.

The number of pounds of steam required per car and train has been shown to be 66 3 lb. per car per hour, equivalent to a trifle more than 7·6 gallons of water condensed per hour, and for a fourteen car train this would amount to about 106 gallons per hour, or about three and one-half per cent. of the storage of a tank of three thousand gallons capacity.

LOSS OF HEAT DUE TO IMPACT OF COLD AIR.

The loss due to convection from the supply mains was included in the previous calculation, and we will now proceed to show how it has been obtained, the unit being the amount of loss per car per hour. To determine this loss we shall use the formula enunciated and explained by Mr. Box in his great work on heat. The notation is r = radius of inside pipe in inches, r' = radius of outside pipe in inches, that is the non-conducting covering measured from the center of the iron pipe cross section. R = the radiant power of the outside surface according to Peclét. A the loss of horizontal cylinder by contact of air. A = 0·421 + (0·307 ÷ r') and Q = R + A C = conducting power of the material of the pipe; N = (log r' − log r) × 2·3 t = temperature of the steam and of inside surface. T′ = external air and radiant objects. U′ = units of heat lost per foot run per hour. Then:

$$U' = \frac{0·5233 \times Q \times r' \times C \times (t - T')}{c + (Q \times r' \times N}$$

The factor 0·5233 is a multiplier to convert these values from a different formula from units lost per square foot to units lost per foot run, which is a more convenient reference for our purpose.

In this case R = 0·323, as we propose to use the best wool felt one inch in thickness as a non-conducting covering for the mains. With any other material, the results will not be equal to these results.

A = 0·589, therefore Q = 0·912; r' = 1·83 (r = 0·83), A = 0·589, C = 0·323, and (t − T′) = 228° Fahr. N = 0·79. Hence we have:

$$\frac{0·5233 \times 0·912 \times 1·83 \times 0·323 \times 228}{0·323 + (0·912 \times 1·83 \times 0·79)} = 39·18 \text{ units}$$

of heat lost per foot run, or say in round numbers 40 units; considering the amount of main piping to each car, including elbows, bends, and thimbles, to amount to 70 feet, we should then have a loss of 2,800 units per car per hour from that source.

The additional loss of heat due to the rapid motion of the car, or to the impact of cold winds, at an average velocity of 18 miles an hour, may be assumed at the same amount per car. We have no authentic data to calculate this actual loss independent of the loss from other causes, but from the results of the experiments on the St. Paul Railroad, where a condensation of 71 lb. of water per car per hour, with the temperature of the car maintained at 80° Fahr., and most of the deck windows open, the external air at zero, and the maximum steam pressure 6 lb. per square inch, our results prove that this estimate is a rational one.

Then we have from walls, windows, floors, and ceiling, and the air within the car an absorption of 58,455 units. Loss from the mains by convection, 2,800 units, and additional loss for rapid motion or impact of cold air 2,800 units, total loss 64,055 thermal units.

VELOCITY OF FLOW OF THE STEAM.

The discussion of this phase of the problem will be simplified if it is borne in mind that the discharge is not of live steam or even of exhaust steam into the air, but that of the discharge of steam condensed into water, for it cannot flow faster than it condenses, because the pressure is maintained as a constant.

The data needed is the cubic feet of discharge, the effective area of the discharging pipe, and the velocity can then be readily obtained. The amount of discharge is 66·3 lb. of steam condensed per hour per car. One lb. of steam at 5 lb. pressure, having a temperature of 228° Fahr., has a volume of 19·72 cubic feet. The total volume of discharge will be 66·3 × 19·72 = 1307·4 cubic feet per hour, or 0·367 cubic feet per second. The area of 1¼ in. pipe whose diameter is 1·38 in. is therefore 1·49568 square inches. Effective area with a coefficient of 0·7 is 0·00727 square feet. If we divide the quantity discharged by the area of discharge, we shall obtain the velocity of the discharge. The quantity is 0·367 cubic feet per second, the effective area is 0·00727 square feet, hence the velocity is $\frac{0·367}{0·00727}$ = 50 feet per second for an inch and a quarter pipe, and 22½ feet per second for a 2 in. pipe.

THE LIMIT OF HEATING POWER.

This factor depends entirely upon the weight of piping which railroad companies will submit to being added to the load of each passenger car. In other words, it depends upon the diameter of the supply main. Given the length of the train and the pressure of steam employed, and the necessary diameter of the supply main can be closely approximated from the results achieved by the researches of Weisbach, Buff, Wantzel, Pecqueur, and others. The diameter is the important factor in any such calculation. In an open circuit, as the Martin is, and as most all steam heating systems are where great lengths of piping in a horizontal direction are required, the steam enters the main and proceeds immediately at its initial velocity, less the frictional resistances it must overcome, to the extreme end of the circuit; and it is the back pressure that fills the lateral branches which run to each car, for the main feed pipe acts as a reservoir, and although a small amount of steam will condense in the mains, it will not alter the conditions of the piping if we suppose the total condensation to take place within the cars. The velocity of flow of the steam depends upon the amount of condensation and its rapidity. This flow depends upon the vacuum formed by the steam condensing. We have found previously that this amounted to about 22 cubic feet per minute. Now, this amount of condensation comes from a surface in each car of 167 sq. ft., or 13·17 cu. ft. per minute for 100 sq. ft. of heating surface.

The 5 lb. pressure of steam is found, from the volume of 1 cu. ft. of water converted into steam at that pressure, to be equal to a column of steam 14,201 ft. high, or, in other words, this is the head which causes the initial velocity of the steam expressed in a column of steam. From the data and researches of the authors we have quoted, we find that the diameter of the main supply pipe can be obtained approximately from the following formula:

$$D = 0·5374 \sqrt[5]{\frac{V^2 L}{H}}$$

The constant 0·5374 having been determined from experimental research, V = the volume of steam required for 100 sq. ft. of heating surface expressed in cubic feet per minute; L the length of mains and branches in feet; H the head in feet of steam necessary to produce the initial velocity; and D the diameter of the main in *inches*.

In all the calculations which follow, we consider the branches to be two inches in diameter. To provide for the resistances of elbows, loops, valves, it is best to express their equivalency in additional lengths of pipe. We generally consider a U loop equal to 40 diameters, a right angle elbow the same, a globe valve 60, for saturated steam. For dry steam, such as used in the Martin system, these resistances are much less, and in short trains would not need to be considered where there are not more than ten to a car.

Making the calculation for a six car train, we have V = 6 × 13·17 = 79, and L = 1,998 ft.; h = 14,201 ft. of steam for 5 lb. pressure; hence by substituting these values we have:

$$D = \left(\frac{(79)^2 \times 1998}{14201}\right)^{\frac{1}{5}} = 2·0845''$$

and the nearest commercial size pipe to this is 2 inches. We append a table showing the results for different length trains calculated by the above formula:

TABLE OF PIPING FOR STANDARD COACH.

Number of Cars in train.	Maximum pressure of steam, lbs. per sq. inch.	Length of main, ft.	Length of branches in straight pipe, ft.	Diameter of main in inches.	Diameter of branches, inches.	Weight per car in lbs.
6	5	396	1,602	2	2	1,221
8	5	528	2.520	2½	2	1,360
10	5	660	3,150	3	2	1,477
12	5	792	3,780	3	2	1,477
14	5	924	4,410	3½	2	1,576
16	5	1,056	5,040	3¾	2	1,632
18	5	1,188	5,670	4	2	1,687
14	10	924	4,410	2	2	1,221
14	15	924	4,410	1½	2	908

The lengths in the above table are equivalent lengths after equating the resistances; the actual lengths are somewhat less. The weights, however, are calculated on the actual lengths. The diameters are given to the nearest commercial size, excepting that required for a sixteen car train; no 3¾ inch pipe being made, its nearest commercial size, inside diameter, would be the 3½ inch pipe. The question now unanswered, what is the limit? Few railroad companies would care to use any pipe heavier than 3½ inch, so with 5 lb. pressure this would be, by the table above, equivalent to a fourteen car train; the only alternative is to use increased pressure, so as to reduce the diameter of the main and the length of the branch piping, and consequently the weight per car. This would, in all probability, be the most economical arrangement consistent with the increased drain implied upon the power of the locomotive.

For trains intermediate in length to those given in the table, all deduced values can be calculated well enough for practical purposes by interpolation. Thus, for an eleven car train, the length of main would be 726 ft., and the length of branches 3,465 ft., diameter of main 3 inches. Frictional resistances, when equated to the retardation of the initial velocity, may safely be estimated at fifty per cent. If, however, the pressure in the cab be set at 10 to 15 lbs. per square inch to insure a greater initial velocity in the main, and the pressure in each car is set so as not to exceed 5 lbs., the diameter of the main for a fourteen car train need not exceed, respectively, two inches and one and a half (1½) inches, and this pressure may be used with perfect safety to the inmates of the cars, when the supply to each car is properly regulated.

RESULTS AND CONCLUSIONS.

In the series of calculations which were undertaken, it was desired to show how much steam was necessary to heat a train of standard passenger coaches, under the extreme conditions of an external temperature of zero degrees Fahr. and an internal temperature of 70 degrees Fahr. Experiments with the Martin heater on the St. Paul road recorded a condensation of nearly seventy-one lb. of distilled water, internal temperature in the cars 80° Fahr., external zero. This is equivalent to about 2·3 horse power per car. Later experiments on the same road have shown a condensation of 42½ lb. per hour when the external air was 26° Fahr., internal temperature and steam pressure not stated.

Under the conditions we have named, we found the heat absorbed by the walls to amount to 252·46 thermal units for a difference of one degree; the temperature of the car walls 69·97° Fahr., and of the windows 22·14° Fahr. The cubic contents of the car proved to be 4180 cu. ft. The total amount of heat required to maintain the temperature of the car for a long train, expressed in thermal units, is 64,055 by direct calculation. The amount of horse power per car equivalent to this is 1 8 horse power. This is a somewhat high value for a short train, as the frictional resistances decrease in something more than direct ratio. The length of two inch pipe required per car to emit the amount of heat required is 267 feet. The Martin systems use a greater length for a shorter car, which we believe is unnecessary. The length of 1¼ inch pipe to furnish the same amount of heating surface as the two inch pipe would have to be 328 feet. The amount of steam condensed per car by direct calculation is 66·3 lb. For a long train up to limits the condensation would amount to perhaps a little more than that. The amount of coal consumed would amount to about 9⅓ lb. of coal per car per hour, and the cost to about 10$\frac{6}{10}$ cents per car per hour. One inventor claims he can heat a car by air gas, developed from gasoline, at a cost of 3 cents per hour per car. The drain on the locomotive was shown to be about five per cent. of its power for a long train.

The velocity of flow is governed entirely by the rapidity of condensation. The ventilation provides for a complete change of air in the car every fifteen minutes, and supplies nearly four cubic feet of air per minute to each occupant of the car. No account has been taken of the heat generated by an adult person in an hour, but it

amounts to 13,300 thermal units for seventy persons in a car, or a little more than a third of a horse power. This factor would aid considerably in warming a train, and if considered would reduce the expenditure of horse power to 1½ horse power per car.

The results obtained show that a severe test has been made, for the car dimensions upon which the calculations have been based are greater than the average American passenger coach; but it illustrates the progressive tendency in American railroad building. The practical results are, first, that as the train increases in length the mains must increase in diameter with any given steam pressure, or the pressure must increase with any given diameter of radiating pipes in the cars themselves. The first expedient increases the dead load of the train, the second increases the direct drain upon the locomotive. The limits of this paper will not permit of the study of this equation of economy; its solution by trial could not be reached perhaps for many years. The size of the mains is governed by the quantity of steam required. Second, frictional resistances in the shape of bends, in the shape of loss of heat by imperfect wrappings or casings, must be reduced. The system of running a U loop under every seat is the worst that could be devised in the heating of a long train. One of the successes of the Gold system, for example, is owing to the small number of bends compared to the length of the radiating surface; when it is remembered that every bend or loop in a two inch pipe adds at least six feet of resistance in length, it will not be necessary to do much thinking to become impressed with the importance of the design in this direction. Third, the retention of the water of condensation as long, and its discharge at as low a temperature as possible, consistent with immunity from freezing, are economical necessities. Fourth, the arrangement of the piping in vertical series rather than horizontal is recommended. Fifth, the objection to the length of time required to make a cold car habitable is to be provided for by stationary boilers located at convenient stations, or to make idle switch engines, which are always about a depot of any size, furnish steam to cars that are side tracked; for the mechanical devices with which each car is supplied are capable of shutting the steam within the car with which the car is charged, and the supply so obtained will maintain a comfortable temperature for an hour or more. Sixth, the means of keeping a car warm, which has been side tracked for some reason or other, are to be found in some plan for storage of the condensed water in some suitable receptacle for such a length of time as it shall have served its purpose; it would not be unreasonable to ask of inventors a suitable provision for such a purpose.

It is more difficult to heat a train of fourteen standard passenger cars with their excessive glass area and their single windows than it would be to heat the same number of Pullman sleepers or parlor cars with their double windows, smaller glass area, and better protected walls and floors, as the writer will undertake to prove in a subsequent paper.

Having described the principles of the modern methods of heating cars by steam, we will proceed to explain and illustrate one of the most important systems now in use.

THE MARTIN ANTI-FIRE OR STEAM HEATING SYSTEM.

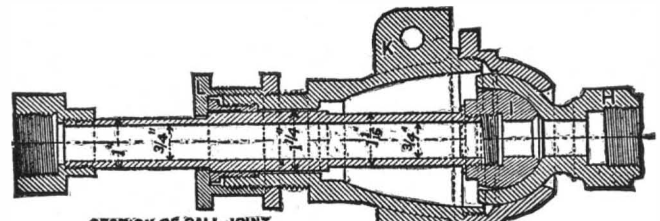
The principles upon which this system depends are few in number and simple in application. It may be classified as belonging to the *open* circulation system, for a suppy main conveys the steam to the radiating surfaces, whence the return main conducts the condensed water into a drain to run to waste. It is also a direct radiation method, as it is called popularly. The supply of steam is taken from the steam dome of the locomotive, and is therefore *dry* steam. The steam is taken at low pressure, that is, from 2½ to 6 pounds per square inch; the maximum pressure, however, is generally five pounds. The steam is received from the dome by an automatic reducing valve; see drawing, Figs. 8 and 9, showing perspective and vertical section. This valve is under the control of the engineer in the pilot of the engine. It is transmitted underneath the cars by 1¼ in. supply mains for three car trains, and by 1½ in. for six car trains, and distributed to each car by 2 in. lateral branch pipes. The supply mains are wrapped with wool felt, and the amount of heat lost by contact in this way is not serious.

Upon entering the lateral mains, the steam is held until it condenses. The water is discharged automatically from the center of the car and at a high temperature, in order to avoid any danger of freezing. In his remarks to the Western Railway Club, in Chicago, the president of the system says this is the fifth winter it has been in use, and that they have not yet had to remove a pipe to thaw it out. While this may be a creditable record from the car heating company's point of view, it is equally an admission of inefficiency in obtaining all the heat that it is possible to obtain from the condensed water, and indicates a source of waste that can be remedied by providing a proper reservoir to store this hot water so that its heat may be given up more completely to the car.

In the *Railway Review* it is stated that it is often possible to heat cars perfectly without showing more than a pound on the gauge, but it curiously fails to mention how many cars this applies to. It can be shut off or received at any car of the train at will. The pipe does not occupy any necessary seating space, so as to interfere with the arrangements of the car, and it is hardly noticeable when once fitted up. In no instance where this system has been put on a car has it been taken off on account of dissatisfaction with the results which have been achieved. This declaration of fact is an assurance that so far as this system is concerned, it has graduated from the experimental stages of its existence, doubting presidents of railroad corporations to the contrary notwithstanding. It is now in use on five railroads, and one railroad company is now experimenting with it in regard to its ability to heat a long train, say twelve or fourteen coaches. Mr. Martin is satisfied that it does not take any more steam for eight or ten cars than the Westinghouse pump. The drain upon the boiler is admitted, by the testimony of all the engineers whose reports the writer has seen, to be immaterial. Just what this drain is, has been approximately estimated. Practically a systematic effort is now being made upon the St. Paul Railroad to ascertain what it is by catching all the condensed water as it comes from the condensing tank. So far as heard from, the water condensed averages about eight and a half gallons per car per hour, or expressed in horse power units would amount to 2·3 horse power per hour per car, or about 18 horse power for an eight car train, or 27·6 horse power for a twelve car train, 32 horse power for a fourteen car train, and 39 horse power for a seventeen car train; but the writer believes that these deductions will be found too high for trains exceeding eight cars, for the maximum horse power required during a severe winter. To obtain a definite result, the tests should be recorded for every day during the three months of December, January, and February, and the mean obtained from a comparison of the results. There are two rows of pipe running along the car, with spurs under the seats, and the supply is regulated by a globe valve near the center of the car. (See Fig. 5.)

DESCRIPTION OF THE DRAWINGS.

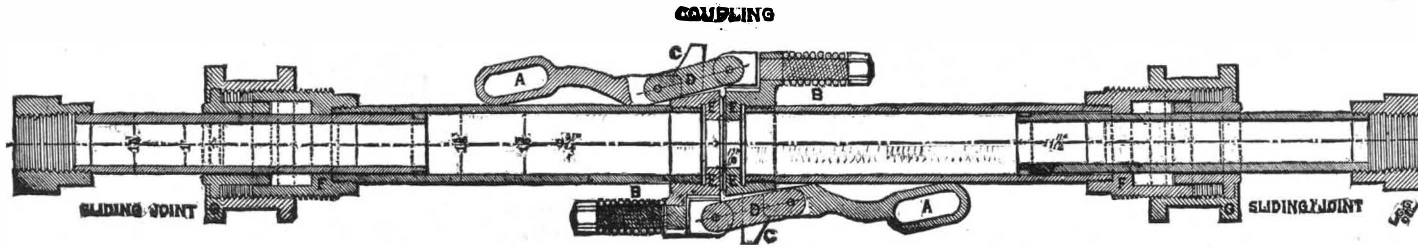
In Fig. 2 is shown the sliding joint, which permits of the compression and pull of the drawheads when the train comes respectively to a stop or gets under way. By refering to drawing, Fig. 5, it will be seen that the interlocking joint is placed just beneath the car coupler, so that it can be reached with readiness. The coupling is entirely metallic, and the strain, which is usually provided for, in the compressed air coupling for example, by a rubber hose, is in this case provided for by the double telescopic joint, which permits of a play, adding that of both joints, of about 12 inches; were it necessary, this play could be increased or diminished by changing the length of the lap in the joint. In Fig. 3 is shown a perspective of the supply main, and its cup and ball joint. In Fig. 1 is a longitudinal section of this joint, and in Fig. 6 is the cup removed from its ball bearing, and in Fig. 7 is the ball bearing itself. The object of this ingenious joint, not new as applied to other mechanical devices to accomplish similar ends, is to allow of a universal movement of the pipe without subjecting it to any vertical or horizontal strain. The joint is fastened upon one end of the pipe running under the car, and its first connection consists of a half ball over which a hemispherical shell is placed, ground down to form a steam tight connection. Outside of the shell there is an outer sphere, which is divided into halves and brought together by a screw thread. The portion of the outer shell marked *k* is bolted solidly to the under part of the car platform, and a steam tight joint is made between it and the pipe entering from the car by the gland and packing box shown at L, Fig. 1. The steam pipes of the two adjoining cars are thus connected by a perfectly flexible and universal joint, which accommodates itself to every variation in the relative positions of the connecting cars. The telescopic joint is of the ordinary construction, and consists of a smooth pipe telescoping into a larger one, with the joint between them held tight by means of a packing box and gland. The real jointure is at the points, E E, Fig. 2. These joints are formed by a metallic gasket between the castings, which are screwed on to the outside pipe of the telescopic joint. The handles, A A, are pivoted at the end to the stud, B, which is drawn inward by the spiral spring about it, so that when the slot in the handle is sprung down over the post, *c*, the springs draw the two faces of the coupling forcibly toward each other, and make the joint steam tight.



SECTION OF BALL JOINT.

FIG. 1.

COUPLING



JOINTS AND COUPLING.

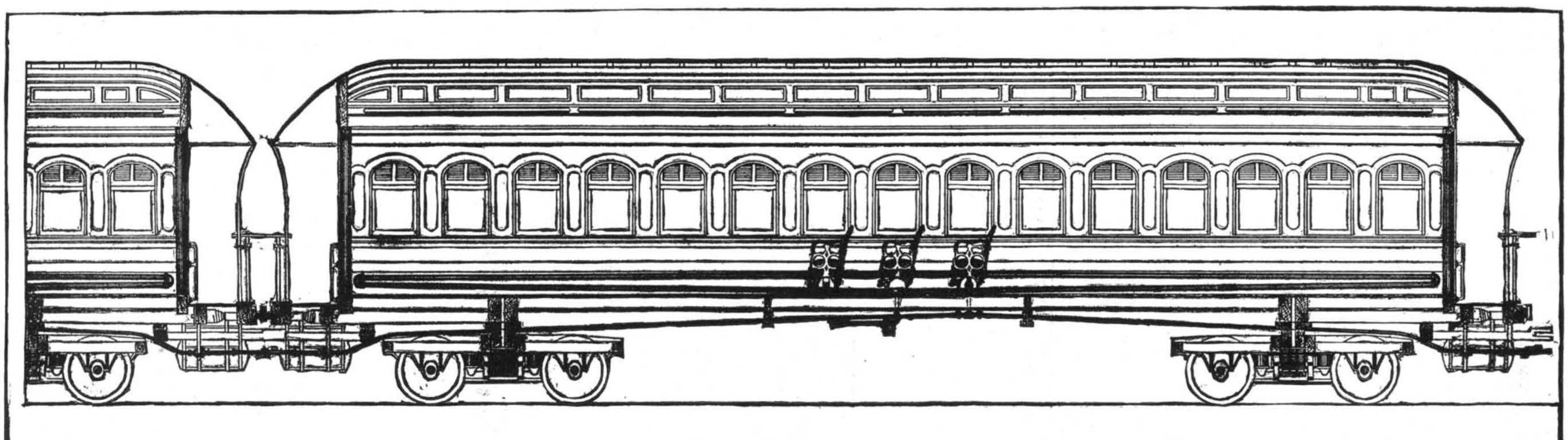


FIG. 5.—HEATING CARS BY STEAM—MARTIN SYSTEM. GENERAL ARRANGEMENT OF PIPING.

A dry pipe is put into the dome, with a cut off valve in the cab, to which is attached a reducing valve: from the reducing valve a small pipe passes beneath the foot board of the engine, to which is secured the metallic joint just described. Under the tender a main pipe is run, carefully wrapped, so as to prevent conde isation. This wrapping has generally been a wool felt, which, according to the careful experiments of Dr. Charles E.

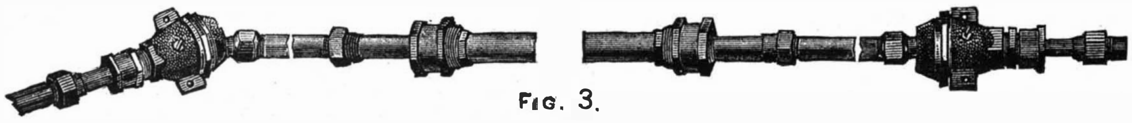
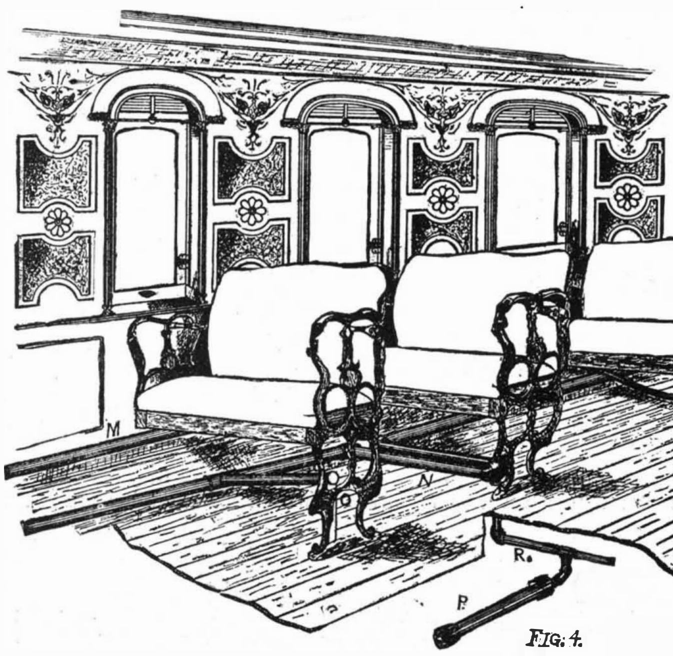


Fig. 3.
VIEW OF PIPING.

Emery, is one of the best non-conductors we have, but it has the disadvantage of crumbling away from the pipe, from the effects of soon becoming charred by the heat of the steam. This subject of jacketing steam pipes, to escape the loss of so much heat by air contact, is of so much importance that it has been necessary to carefully study the effects of different materials as to their non-conducting capacity. The whole philosophy of non-conducting materials depends upon the theory



VIEW OF INTERIOR ARRANGEMENT.

of divided air space, and as mineral wool No. 2 ranks next to wool felt and is indestructible by steam, a valuable suggestion was made by the editor of the *Journal of Railway Appliances*, in a conversation with the writer, and he takes the liberty of making it public, viz., to first cover the pipe with a certain quantity of mineral wool No. 2, then wind wool felt about this and cover the two jackets with a canvas lining. This would secure the wool felt from destruction, and at the same time utilize the non-conducting powers of the two best

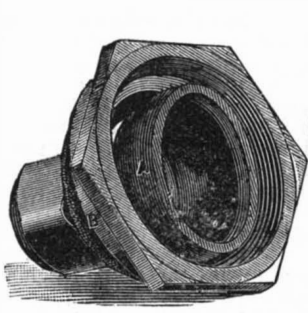


Fig 6

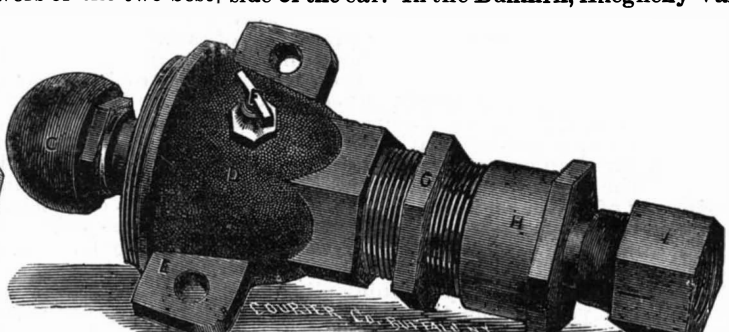


Fig 7

BALL AND SOCKET JOINT.

non-conducting substances which we possess. Clay coverings and cement coverings would be impracticable on a railway car, because such coatings would be liable to break off or crack in spots, owing to the vibration of the train and sudden shocks which every railway car is exposed to. It is quite clear from experience that the non-conducting material must be of such a

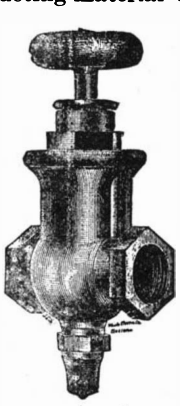


Fig. 8.—REDUCING VALVE.

character that blows and vibrations of any kind will not make it crumble.

On each end of the main, the metallic joints are screwed, strongly braced to the tender frame, just as they are to the cars. The metallic couplings are so arranged that the moment the cars separate thirteen or fourteen inches, the ring at *x*, Fig. 5, strips off and they come apart, and let all the steam out of the car. It is only a puff and it is gone, so that at the next instant there would be no danger to any one in the car.

The "Curtis" reduction valve, of which we show a vertical section, see Figs. 8 and 9, consists of two chambers. In the lower one a metallic cup slides up and down, and is held down to its seat by the back pressure from the train, which is set to the maximum pressure required. The back pressure of the steam, or rather the relaxation of pressure of the steam from the pipes upon a disk of phosphor bronze releases the upper cup, and the spindle lowers, steam rushes in from the dome, pushes the spindle and diaphragm up and presses the lower cup to its seat, and the connection is shut off from the dome; thus this intermittent automatic action goes on, the amount of pressure being fixed at will. Valves depending upon balanced levers by means of weights, or gravity valves as they are called, are not to be trusted to the oscillating, uneven, and uncertain motion of a locomotive, although they perform their work perfectly on station ary boilers.

The distribution of the steam through a train depends of course upon the arrangement of the cars. Where no heat is required, it may be shut off from the branch pipes, or it may be confined to one set of branch pipes. Through express or baggage cars it is the practice to run but one main pipe, and that upon but one side of the car. In the Dunkirk, Allegheny Valley, and Pittsburg R.R., two radiator pipes are run along each side of the car without any covering. One of the centrally located seats has a spur loop under it, about two and one half feet in length outside face of loop to outside face of radiator main, and its adjacent seat has a single stem terminating in an angle valve, shown in Fig. 4, by which the steam is let into radiating pipes, M, or

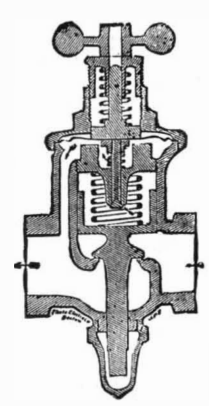


Fig. 9.—VERTICAL SECTION OF REDUCING VALVE.

shut out in main pipe, S, thus enabling the train men to shut it out of any car without affecting any other in the train. The plan and elevation in Fig. 5 show how the pipes are distributed. The main feed pipe, wrapped with wool felt, is shown by dotted lines in the plan. This pipe is one and a half or preferably two inches in diameter, is underneath the floor beams of the car, highest at the center, and deflecting equally toward each end of the car. In the car itself the pipes slope toward the center. On each end of the main under the car are screwed the metallic couplings; see Fig. 5. At the center of the main supply pipe,—see Fig. 4—two branch pipes pass off and up through the floor on each side of the aisle, as indicated in the elevation, Fig. 5, and seen at R, Fig. 4. On each side of these branches, in dotted lines, are valves to prevent the steam blowing off in rear of train, should the car be the rear one. Steam passes from these branches, N, into radiating pipe, M—see Fig. 4, where O may be seen leading to the main radiating pipe, M. It divides into two currents, passes both ways to each end of the car, and returns to the center, N, by the sloping arms shown in elevation, Fig. 5, and passes down through the return bend—see Fig. 4—into R, where it is discharged into the trap, P, as water.

The trap is simple in construction, being an elongated iron box with a strap of spring brass fastened at each end, and a valve suspended in the center. The seat is adjusted to the valve to open or close it. The steam acting on the strap of brass inside the iron box bows it up and holds the valve against the seat. The strap straightens in the water, which opens the valve and lets the water escape.

Where it is necessary to carry the condensed steam to a terminal point for the discharge of the water, a tank is provided, and its contents will not be in danger of freezing if discharged within a specified time. On surface roads, the tank may be dispensed with and a steam trap of simple construction used, which discharges all condensation in the form of a fine spray of hot water. It is claimed that these traps will not freeze while in action, exposed to a temperature from 22° to 24° below zero, as there is a constant grade of the pipe from the time the steam enters them until the condensation reaches the trap.

The cost of this system is $200 per car, including everything.

LIGHT DRAUGHT TWIN SCREW VESSEL FOR NICARAGUA.

Opposite we show a steel twin screw light draught steamer, being the last addition to the little fleet of steamers which keep up the communication from the Atlantic to the Pacific Ocean by lake and river across the State of Nicaragua in Central America, this being one of the alternative routes for a canal instead of Panama, and looked upon favorably by the United States of America. Six years since, the builders of this vessel, named the Progreso, launched the first steamer, the Amelia, on Lake Managua, which, together with the railway then being constructed, opened up steam communication from the port of Corinto to Managua, the capital of the republic, *via* Momotombo. Since that time, a railway has also been constructed from Managua to the town of Granada, on Lake Nicaragua, and other steamers on this lake and River Juan complete the communication from Corinto on the Pacific to Grey Town on the Atlantic side. Last year the government decided to accelerate the mail service to and from the capital, and a subsidy was offered to the steamboat company for this object, and with a view to obtaining a light draught steamer. For this purpose the managing director came to London, consulted Messrs. Edwards & Symes, whose boats had given them so much satisfaction during six years' service, and an order was placed with the firm for a twin screw steamer, to be built of steel, suitable for passengers and cargo, with a large deck area to meet the requirements of the government for military transport, with a guaranteed speed of 13 knots per hour on a draught of water not exceeding 5 ft. aft and 2 ft. forward, the contract not to be completed until the vessel was afloat on the lake, and the speed attained with wood for fuel to the satisfaction of the purchasers. Messrs. Edwards & Symes have for many years made light draught twin screw steamers a specialty, having constructed some twenty-four, both with high pressure and compound surface condensing engines, and the result attained by this vessel illustrates their practical experience in this class of work.

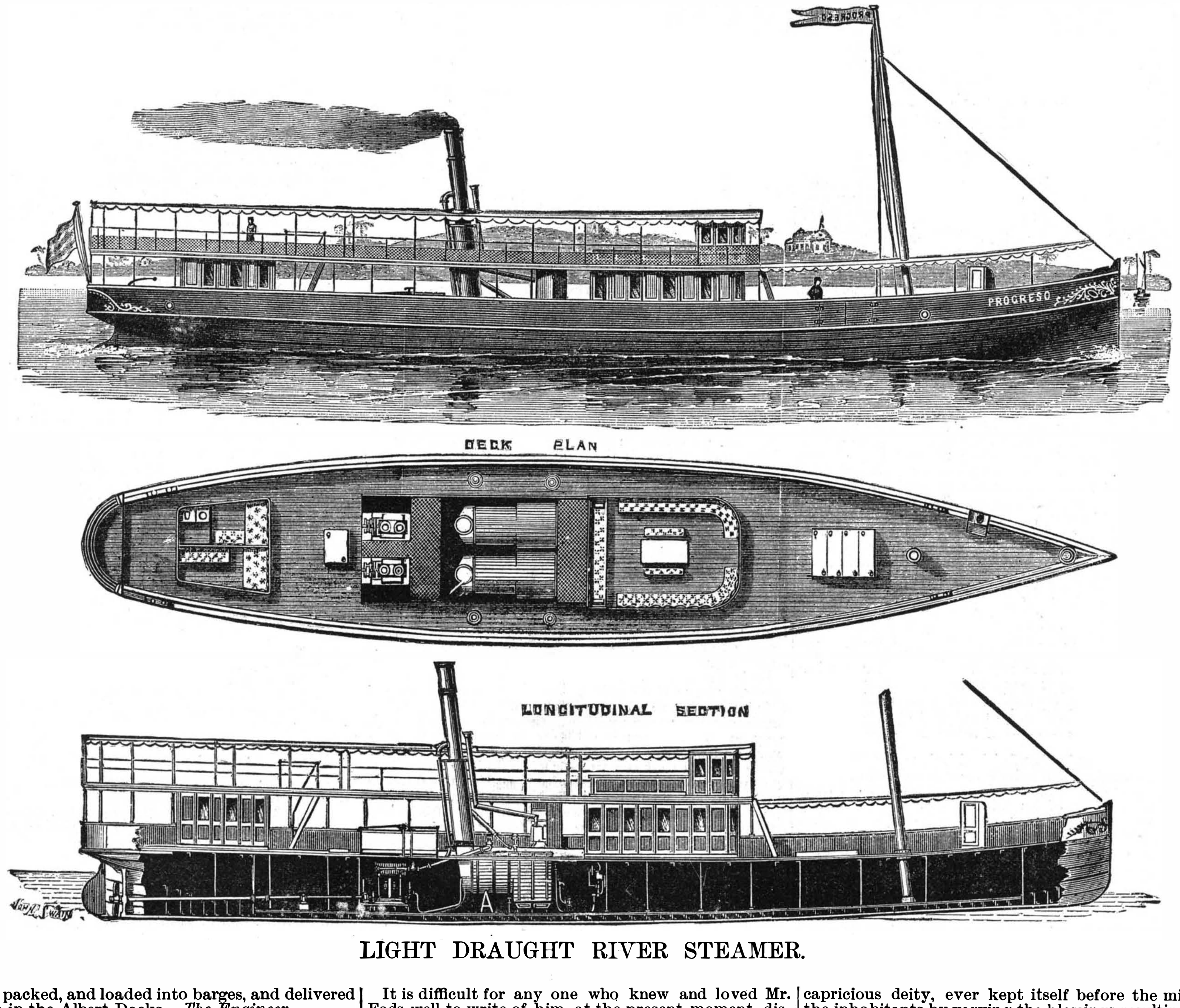
The illustration shows the construction of the boat so fully that we need only give the leading particulars of its construction for it to be fully understood.

She is constructed entirely of steel of the best quality, manufactured by the Steel Company of Scotland, and is 135 ft. long, 24 ft. beam on deck, and 8 ft. deep, and divided into four compartments by bulkheads. The forward compartment is for stores and chain locker. The compartment forward of the fore engine-room bulkhead is for cargo, and is about 50 ft. long, and the compartment abaft the engine-room bulkhead is also for cargo. On deck is constructed forward a highly finished polished teak deck house, with elliptic front, the overhead and inside being paneled and gilded, some of the panels fitted with mirrors. The sashes slide up and down, and are protected with brass guards on frames. Sliding Venetian blinds are fitted to use when it is necessary to slide down the glass sashes. The deck house top is entirely separate from the sun deck, so that a current of air flows between them. The after deck house is of the same style and finish, and fitted up internally with ladies' cabin, restaurant, w. c., etc. A neat galvanized windlass is fitted forward, and a warping capstan with a brass head fitted aft. The awning or sun deck covers over about 90 ft. of the main deck, and is supported on the outside edge with tubular stanchions, and surrounded with stanchions and handrails, and wire netting, and awning stanchions supporting an awning over this deck. Teak batten seats are arranged round the after parts and at the center line for seating the passengers, leaving a good, spacious deck on each side for promenading. At the forward end of the sun deck is fixed a deck house with a circular glass front, giving complete command ahead and on each side to the steersman. Inside is placed the steering wheel and gear and separate engine-room telegraph to each engine.

The propelling machinery consists of two pairs of high pressure engines, with cylinders each 11 in. diameter and 12 in. stroke. These engines are of the inverted direct acting type, made right and left hand, so that all the working parts are under the eye of the attendant at once. All the working parts are of steel, with steel crank and propelling shafts. The valve gear is of the ordinary single ported type with common slide valves, with link motion reversing gear with two

eccentrics. The levers for reversing the engines and the starting valve gear are all carried up to the engineer's platform on the main deck. There are two boilers, one for each pair of engines, constructed of mild steel, of the locomotive type, 12 ft. 3 in. long, 5 ft. diameter in the barrel, with 121 tubes, stayed for a working pressure equal to Lloyd's rules for 90 lb. per square inch, and are fitted up quite independently of each other in every respect, so that one engine and boiler is complete in itself, or by means of the arrangement of valves and pipes, either engine can be driven by either boiler or both by one boiler in case of need. Each boiler is supplied with water by the engine feed pump. An injector and a donkey pump and feed water heaters are fitted. There is also a bilge pump fitted to each engine, and the donkey is made to pump from the bilge. All the working parts of the engines have large surfaces for running at 250 revolutions per minute, and with wood as fuel ample steam was generated, and the steamer with its machinery gave great satisfaction.

A report received from the owners states that the Progreso has entirely fulfilled the conditions of the contract under which she was built, having attained the stipulated speed of 13 knots, and her draught of water does not exceed 5 ft. The contract for this vessel was signed on September 30, 1885, and the whole was to be delivered by the first week in 1886. But the contractors had everything completed and delivered by December 18th, 1885. That is, in the short space of about ten weeks, this steamer and machinery were constructed, packed, and loaded into barges, and delivered alongside in the Albert Docks.—*The Engineer*.



LIGHT DRAUGHT RIVER STEAMER.

JAMES B. EADS.

THE grave has recently closed over one of America's most gifted engineers, a man who has left behind him monumental testimony of his greatness in the works which he created, and in the hearts of his friends a loving memory and a deep sadness that one so able should have been called away before his work was done. We have so recently given an outline of Mr. Eads' career that it seems superfluous here to repeat the story, and it is easier to dwell with sorrow on the recollection of the great but simple characteristics of his private life, and on the rare qualities and energy he possessed, than to make a record of his actual work. And, indeed, though he did so much throughout an ever busy though unfortunately not sufficiently prolonged life, his engineering triumphs were not half so great as his diplomatic victories, for Mr. Eads was essentially an engineer of men as well as of materials, and to overcome moral obstacles afforded him as much satisfaction as to subdue physical difficulties.

No matter to what nationality Mr. Eads might have belonged, he must have left behind him an honored and much loved name, but he could only have developed his striking individuality in the United States, where circumstances moulded, strengthened, and directed his great natural gifts, and at the same time afforded them a wider scope for development than any other country could have done.

To compare him with M. De Lesseps is to compliment that marvelous man, whose name suffices to conjure millions from the pockets of French petty capitalists. But M. De Lesseps lays no claim to being an engineer, only a diplomat and financier, while Mr. Eads was both of these and an engineer as well, and throughout the whole of his career he never had the privilege of obtaining capital from an emotional, hero-worshiping peasantry, but always from close-reasoning, far-sighted bodies of men, who would never yield a dollar except on evidence that would have satisfied St. Thomas himself. It seems but yesterday that M. De Lesseps was in the United States, and that these two great men were feted together and paid to each other graceful and well merited compliments that were none the less truthful because they were after dinner speeches.

Like A. L. Holley, whose memory remains ever green with us, Mr. Eads was known and esteemed as much on this side of the Atlantic as on his own. Until recently he was almost a yearly visitor to London, where in professional circles his coming was anticipated with pleasure, his going with regret. But for several seasons before his last stay among us, those who knew him best noted with sadness that his marvelous vitality was not so great as of old, that his energy was burning out the delicate organism, and though his mind was clear as ever, his simple eloquence as fascinating, and his power of argument and carrying conviction as remarkable, still there were signs of physical weakness, which he would sometimes confess to, with a fear that he might not live to see his last great scheme on the road to completion.

It is difficult for any one who knew and loved Mr. Eads well to write of him, at the present moment, dispassionately, but those who enjoyed that privilege (and it is a pleasure to remember how numerous they are in this country) will know that these few inadequate words of ours only fail to do him justice. He was a great man, admired for his genius and beloved for his simple and winning nature.

To back his opinions with his own money was very characteristic of the man, to attempt (and carry out) more than had ever been done before was also characteristic. The Mississippi ironclad fleet that won brilliant victories before it had been paid for was an illustration of this; so was his great work of regulating the South Pass of the Mississippi; so would have been, if death had not been inexorable, his last bold and favorite scheme of the ship railway across the isthmus of Tehuantepec.

Possibly—probably perhaps—that scheme may be now abandoned, for the mantle of Mr. Eads' individuality can descend on no one, and his personal influence was the one thing needful to steer the great venture among the quicksands of incredulity and prejudice and the rocks of opposition. The most weighty professional opinions in this country and the United States have been declared in favor of the undertaking, so that, if it should proceed no further, at least Mr. Eads' reputation stands secure in regard to what, without such indorsement, might have been branded as a wild and visionary project.

It would be interesting to review, did space permit, the seamy side of Mr. Eads' undertakings, and to relate the story of the difficulties and opposition and hostility he encountered from members of his profession, especially in the greatest of his finished works—the South Pass of the Mississippi. But it must suffice us to show how often and completely he demonstrated the soundness of his own views and put his enemies to shame by the results he achieved.

Mr. Eads was born on the 23d of May, 1820, and consequently had nearly completed his 67th year at his death—not a long life if counted by years, but if measured by achievements, exceeding that of most men of his generation. His boyhood was spent in the village of Lawrenceburg, in the State of Indiana, where until the age of thirteen he lived the life of the average American lad of the time, picking up what scanty semblance of education the place provided.

Business troubles caused his father to transfer himself and his family to the city of St. Louis, and here the boy was brought into contact with the Mississippi, which was to form his constant study and to prove the foundation and the capital of his professional reputation. But for a time he was occupied in a dry goods store, where his days were spent in measuring cloth and ribbons; some little snatches of study were gained in the evenings, and these were aided by books from his master's library, but we may be sure that there was but little leisure time for shop assistants at the period of which we write.

After five years spent thus, Mr. Eads became clerk on a river boat, and thus had the many problems of the Mississippi always before his eyes. In the town he must have heard of it continually, for the river, like a capricious deity, ever kept itself before the minds of the inhabitants by varying the blessings resulting from its presence, with ruin and disaster. Vessels were continually going aground in the shifting channels and being totally lost with their cargoes, smiling plantations were engulfed in a night, and swept as silt down to the Gulf of Mexico, while floods were matters of annual occurrence.

These troubles, and the possible remedies for them, formed topics of conversation, and filled the local press. It was, therefore, impossible that a thoughtful St. Louis boy, with a natural bent toward engineering, should not have been acquainted with them, even when confined behind a draper's counter.

But the time was not ripe for great engineering schemes, and even if the hour had come, the man was yet only a boy, and was not furnished either with knowledge or experience. There were, however, plenty of smaller problems daily confronting the inquiring eye on the river, and to those Eads applied himself. The snags and banks around which the shifting channel wound proved fatal to many a vessel carrying cargo which would have repaid the expense of salvage if only there had existed means for this purpose.

He, therefore, invented a diving-bell boat, which was so successful that it was afterward remodeled on a large scale, and fitted with powerful pumps and other appliances for the recovery of ships and their contents. With this plant the subject of our sketch acquired the most intimate acquaintance with the great river, as he not only sailed over its surface, but walked on its muddy bed, watching the constant process of deposi-

tion and scour which is ever in operation. This work, too, took him to all the dangerous spots, compelling him to dog the footprints of disaster until its ways became perfectly familiar to him.

The knowledge he thus acquired led him to propose a scheme for the removal of snags and wreck obstructions. The plan obtained the approval of the House of Representatives in 1856, but the adjournment of Congress prevented it obtaining complete official sanction. At the same time that this proposal was afoot, Mr. Eads was engaged in erecting glass works in St. Louis, for he had left the steamboat service at the age of twenty-two, and had established himself as an engineer.

We cannot follow the steps of his practice, and it is sufficient to state that his great ability, assiduous patience, and above all his resolute will brought him work that resulted in fortune and a fame which, spreading over the Mississippi valley, reached into the official bureaux at Washington. Hence, when the rebellion of the South burst forth, almost shaking the Federal Government from its seat, an offer made by Mr. Eads to build and equip ready for armament seven iron-plated gunboats in sixty-five days was accepted, and the contract was placed in his hands on the strength of his reputation.

The tale of the building of these steamers has often been told—how on August 7, 1861, the timber to form their hulls was standing uncut in the forest, how the rolls for the manufacture of the armor plates were not in existence, how the engines were nothing but pig iron and bars, and how in forty-five days the first of the vessels was launched with engines and boilers aboard, and how the remaining seven, not to mention eight of larger proportions, followed in rapid succession, and did good service to the State at the capture of Fort Henry and in the conquest of Donelson and Island Number Ten.

This feat is unparalleled in the history of the world, and shows that great as Eads was as an engineer, he was still greater as an organizer and as a leader of men. At his word, before agreements could be framed or prices discussed, the entire engineering manufacturing capacity of several States was set to work at the highest possible pressure, and was continued day and night, Sunday and week day, in spite of all manner of difficulties, not excepting those arising from the impecuniosity of the government.

When the Civil War had died away, and material progress again appeared, the necessity of bridging the Mississippi became too urgent to be further delayed. A bill approving the project was passed in 1865, and the work was commenced in August, 1867. The river was crossed in three arched spans of 502 ft., 520 ft., and 502 ft. respectively, the bridge costing 1,300,000*l*. The piers were sunk to a depth of 136 ft. below high water, and weighed, the one 40,000 tons, and the other 45,000 tons.

When we consider these figures, and also remember that the bridge was built nearly twenty years ago, before engineers had the materials or the experience of to-day, it was no wonder that the people of St. Louis expressed their sense of the value of the structure and of the genius of their townsman in an ovation the like of which was never seen in America before or since.

This occurred in July, 1874, the designing and building of the bridge occupying nearly ten years of Mr. Eads' life, that is, from the age of forty-four to fifty-four. Of course he did many things besides during the time, for the engineer of a project such as this will have calls on all sides for advice and aid, and might find work for every hour of the twenty-four.

In writing a sketch of the career of a busy man, it is difficult to give due prominence to the details of his daily life, and not to concentrate all our attention on his great achievements, thus giving the reader the impression that his work was confined to a few matters of great importance, forgetting that a reputation must be gained and maintained in smaller matters before the opportunity of attacking great problems can be obtained.

Scarcely was the bridge finished before Mr. Eads returned to a project which had been germinating in his mind for years—the construction of an entrance to the Mississippi worthy of its importance. That mighty river system which debouches below New Orleans has a network of 100,000 miles, and passes through nearly 1000 million acres of the most fertile land of the United States. Yet with its vast extent it had only the poorest access to the ocean, for at the mouth its waters were spread out nearly two miles wide, and rolled in a languid, shallow current through a delta which was constantly growing larger from the silt which dropped from the slow moving water.

Vessels constantly grounded, and the value of New Orleans, despite the importance of its geographical position, stood far down in the list of American commercial ports. Mr. Eads conceived the idea of making a 30 ft. channel through the bar, deep enough to permit the entrance of the Great Eastern and of every other vessel afloat, and he found men of capital with sufficient confidence in him to enable him to make an offer to Government to do work to the value of 10,000,000 dols., the payment of which should be dependent on the depth of water attained, beginning with 1,000,000 dols. when a 20 ft. channel was constructed, and only completed when a depth of 28 ft. had been maintained for ten years. The plan he proposed was to construct jetties founded on woven willow mattresses at each side of the proposed channel.

The obstacle these offered to the current would bring about a silting up of the shallows, and would confine the flow to the channel, which would in this way be scoured out and deepened. The scheme was attacked on all sides—by those who had proposed other plans, and particularly by the United States Engineer Corps, who hitherto had had the monopoly of public works of this kind. Mr. Eads threw himself into the agitation with characteristic American ardor, and both on the platform and in the press he proclaimed the accuracy of his views and the blessing that would result from their adoption.

In the end he was obliged to content himself with a compromise, and to confine his operations to the South Pass of the delta, and carry them out on a relatively small scale. In 1875 he commenced his work, and in July, 1879, he had constructed a channel 26 ft. deep and 165 ft. wide, and since then the depth has increased, with the effect of raising New Orleans from being the eleventh to the second export city in the States. The labor and difficulties were immense, and at one time the whole scheme was on the brink of ruin. The promoters were quite out of funds, the workmen were unpaid, and had not Condress voted money in advance of the specified time, the undertaking must have collapsed. Yellow fever also broke out and drove away the laborers, and had not Mr. Eads been a great deal more than an engineer, his reputation would have been buried in the mud flats of the delta, and his scheme branded as a failure, instead of being one of the most remarkable examples of hydraulic engineering of the world.

No account of Mr. Eads would be complete without a reference to his ship railway, by which he proposed to lift full sized laden vessels out of the Atlantic, and after carrying them across the isthmus of Tehuantepec, to deposit them safely in the Pacific to continue their voyages. But the demands of our space forbid us to do more than mention it, and those who are interested in this matter will find a full account of it in our past issues. Mr. Eads spent some weeks in this country in 1884, and gained a host of influential friends for his scheme, and if he had lived, would never have allowed it to drop. The occasion of one of his last visits to this country was the Parliamentary inquiry into the merits of the Manchester ship canal, he having been retained to give evidence by the opposition at a fee which was the largest ever yet paid to an engineer. This evidence caused the rejection of the scheme, as it then stood; and the modification by which the canal was laid out along the shore of the wide part of the Mersey, instead of being led in a trained channel through the sandy flats, was due to his advice. Two years ago Mr. Eads was personally consulted by the Emperor of Brazil as to the harbors of his kingdom; for although his work was chiefly confined to the United States, yet he enjoyed an almost universal reputation, established on the secure foundations of his own work.—*Engineering.*

PRINCIPLES AND PRACTICE OF ORNAMENTAL DESIGN.*

By Lewis Foreman Day.

Lecture I.

When this series of Cantor lectures was first suggested, I was told that I must not take for granted any special knowledge of the subject on the part of my audience. If, therefore, what I have to say should appear to any of you rather too elementary, I must claim your indulgence. What I have taken for granted is, that you want to know. My idea is to tell you what I know on the subject of ornament, and to be as little tedious as I can in the telling.

One more word of preface, as to the illustrations on the walls. They are chosen more with a view to illustrate what I have to say than for any intrinsic interest in them. They are all numbered, and they are arranged (I hope) consecutively, so that, if you will keep an eye on them as I proceed, it will help you to follow me, and even to anticipate my meaning, perhaps.

THE ANATOMY OF PATTERN DESIGN.

Pattern comes of repetition. Many a pattern bears on the very face of it the evidence that it grew directly out of the necessity of repetition. You see this very plainly in the checker, which is the product of plaiting. In the lozenge or diamond pattern, which is anticipated in the meshes of the simplest form of netting. In the herring-bone, or zigzag, which is derived from basket work. Even the elaborate interlacing ornament of Arab art is based upon an arrangement of cross lines, very much as you may see them in the common cane bottomed chair.

It is more than probable that some mechanical necessity gave rise to *all* geometric pattern. Certainly it is impossible to plait, net, knit, weave, or otherwise mechanically make, without producing pattern. It may be so small (as it often is in weaving) that the warp and weft are invisible to the naked eye. But it is there, and all that remains for us to do is to efface it all we can, or to make the best of it. Out of the determination to make the best of it has grown much of the most beautiful pattern work. To neglect this source of inspiration, therefore, to say nothing of the attempt to suppress it, would seem to be wasteful of opportunity to the last degree.

The very repetition of parts, then, produces pattern, so much so that one may say that wherever there is ordered repetition there is pattern. Take any form you please, and repeat it at regular intervals, and you have, whether you want it or no, a pattern, as surely as the recurrence of sounds will produce rhythm or cadence.

The distribution of the parts need not even be regular. The wave marks on the sand, the veins of marble, the grain of wood, the crystallization of the breath upon the window panes, the curl of the hair, the very features of the human face, resolve themselves into pattern. So distinctly is this last the case, that the ornamentist finds himself continually devising, *malgre lui*, patterns that remind one of faces. There is room for speculation whether it may not have been with a view of escaping this danger, or anticipating it rather, that the designer first took to the deliberate use of those masks and grotesque heads which form so prominent a feature in ornamental design.

The popular idea of the process of ornamental design is that the artist has only to sit down before a piece of paper, and, spider-like, spin out the fancies that may crowd his fertile imagination. Indeed, there is scope in design for all his fancy, but he is no Zeus, that ornament should spring, Pallas-like, full grown from his brain.

Ornament is constructed patiently (I will not say laboriously, for the artist loves the labor), patiently built up on lines inevitable to its consistency, lines so simple that to the expert it is not difficult to lay bare its very skeleton; and just as the physiologist divides the animal world, according to anatomy, into families and groups, so the ornamentist is able to classify all pattern work according to its structure. Like the scientist, he is able even to show the affinity between groups to all appearance dissimilar, and, indeed, to point out how few are the varieties of skeleton upon which all this variety of effect is framed.

Before enumerating these varieties, let us suppose for a moment a man to imagine (and this is by no means an imaginary case) that he will make to himself a repeating pattern without regard to its logical construction, as though in his domain there should be no skeletons. That would be, from my point of view, a profoundly foolish thing to do. But, more than that, it is impossible. He may design a unit in which there is no repetition and no formality, but the moment he repeats that unit, the very order of its repetition proves to be, if I may call it so, the cupboard in which the skeleton will be found.

It might be imagined that by designing in some such haphazard fashion as I have just supposed, the artist would secure to his design a freedom of line, an absence of formality, not readily to be obtained by adopting the more systematic method. But this is not by any means so. If, indeed, the design be of that absolute uniformity all over that there is no one feature in it more pronounced than another, it may pass muster notwithstanding the want of backbone. But that is not to claim much for it as a design. And it was scarcely worth the pains to take exceptional measures merely to this insignificant end.

If, on the other hand, a design be above the level of insignificance, there must be in it some dominant feature or features which, when many times repeated, will appear more prominent than ever. It is to these features that the eye will irresistibly be drawn, and it is the lines they take in relation one to another which will assert themselves. It is hardly to be expected that if these lines have never been taken into consideration they should come out very satisfactorily, and, as a matter of experience, they always come out awry. You must all have suffered more or less from wall-paper and other patterns in which certain ill-defined but awkward stripes impressed themselves upon you. And you may have imagined possibly, if you thought about it, that this effect of stripes came of working upon vertical, horizontal, or diagonal lines. It was much more likely the result of not working upon definite lines at all. A designer who knew the A B C of his business would make sure of lines not in themselves offensive. He would counteract a tendency to stripes in one direction by features directing the attention otherward. And he would so clothe any doubtful line that there would be no fear of its asserting itself, as in its nakedness it might. He foresees the danger (and it is a danger even to the most experienced of us) and he is forearmed against it. The mighty man of valor who disdains to be trammeled by any such incumbrance is without defense against contingencies practically certain to arrive. It is only by a miracle, or a fluke, that he can escape failure. The overwhelming odds are that the petty considerations he has despised will be quite enough to wreck any venture he has dared in defiance of them.

Since, then, it is practically inevitable that there shall be definite lines in ornamental design—seeing that if you don't arrange for them, they arrange themselves—it is the merest common sense to lay down those lines to begin with, and, in fact, to make them the skeleton or frame work upon which you build up your pattern.

Let me now lay bare these skeletons for you. You will see that they are, after all, very few.

First in order of obviousness comes the *stripe*—and very early also in order of invention, for the loom must from the beginning have suggested the stripe pattern. It grows out of it. But the stripe carries us only a very short distance in the direction of design. For immediately you make any break in the repeated line, the recurrence of that break gives other lines in the cross direction. Take a series of horizontal bands broken by rosettes at equal intervals. If the rosettes fall one under the other, they give upright lines. If they are shifted, you get diagonal cross lines. Or, if the line itself is broken, as in the case of a series of waved lines, or, still more plainly, in a series of vandykes, the turn of the waves, or the point of the zigzag, when repeated, it gives the cross line just the same.

And so we come at once to the vast order of patterns constructed upon cross lines—probably quite the first in point of time, arising, as it inevitably does, out of the very primitive art of plaiting.

By the simple interweaving of strips of two different colors we get at once the *check* or chess-board pattern. If the strips are all of one tone, then the lines of intersection make a lattice or basket work pattern.

The simplest form of check or lattice is when the crossing is at equal intervals and at right angles. Vary the interval, and you have all manner of plaids and tartans. Alter your front of view (or turn the design forty-five degrees round) and you get *the diamond.* The difference in point of view makes no real difference in plan—a stripe may take any direction, but it is always a stripe. But if we alter the angle at which the lines cross, we get not only a fresh variety of shapes, but we get also a diamond shape, which, for the sake of clearness, I will call *the* diamond, which plays a very important part in the next order of patterns, at which, however, we have not yet arrived.

Returning to our network of cross lines, there is no particular reason why they should always be filled in alternately, *a la* chess-board. They may just as well be grouped in twos, threes, fives, and so on—resolving themselves into patterns of great variety and even of intricacy, as in the case of the fret, and thus an ever increasing range of pattern work discloses itself, all built upon one and the same constructional scaffolding.

This theory, however, must not be pressed too hard, or you may squeeze something very like a false idea out of it. It might be contended that all patterns are formed on the square, or all patterns, at least, that can be woven, the threads forming the squares on which the design is laid. This is obviously absurd. The only patterns built on the square are those in which the artist (consciously or not) worked upon those lines. The actual squares of a coarsely woven scroll, or of a pattern in Berlin wool, belong not to the pattern, but to its translation into a textile fabric.

If instead of the chess-board we take the lines of the lattice and work upon them, we get, without departing from those lines (only intermitting them), a wonderful range of interlacements and the like. From the intermission of the lines results a kind of spot pattern, more or less free, which might be mistaken for a distinct order of design. But it is only a variety. It really matters little whether a design is constructed on geometric lines, or only arranged so that it falls within

* A series of four lectures recently delivered before the Society of Arts, London. From the journal of the society.

them. The skeleton, when you come to dissect the two, is the same in either case; and I would ask you to bear in mind that what I have said, and am saying, applies quite as much to sprigs, spots, and all so-called free patterns, as to those in which the constructional lines actually occur as lines. You have not done away with construction when you have succeeded in keeping the scaffolding out of sight. Again, the use of the broken line instead of the straight makes no difference except in effect. The skeleton is the same, though you use a sort of conventional flash of lightning instead of a straight line.

So far we have had to do only with the simplest of all possible schemes, in which at most two series of lines intersect one another. The introduction of a third series of cross lines constitutes a new departure, and a most important one. Cross the chess-board by a series of lines bisecting the right angles (cutting the squares in half, that is to say), and you have a new form to work upon—*the triangle*.

But it is the equilateral triangle which is the most useful factor in design. This is obtained by crossing an elongated diamond pattern by a series of lines bisecting its obtuse angle; and once you have the equilateral triangle, you have only to group the units to get the hexagon (a group of six triangles), the star (a group of twelve), and other shapes, such as that formed by a group of eighteen triangles, or of three hexagons.

Our scope is now immensely widened. We have the basis of an infinity of geometric patterns, such as we find in Byzantine mosaic work and in its Moresque derivatives.

By the use of a fourth series of cross lines at right angles to the last, again a new shape is evolved. If, that is to say, you cross the square lattice diagonally both ways (cross it by itself, that is), cutting up each square into four, you get out of these lines the *octagon*, but not an equal-sided one; that is built on a different lattice.

The octagon, however, is not a unit which will of itself form a diaper, as the hexagon will. It is only in connection with the square, diamond, or other four-sided figure that it will repeat. Nevertheless, this new series of lines gives us new varieties of radiated patterns. Witness, again, the elaborate interlacings of the Arabs, all of which, even the most magnificent, are closely related to the seat of a common cane-bottomed chair.

It is possible to carry the principle of *radiation* further still. You may, for example, cross this more elaborate lattice by a lattice like itself—but you get by that means rather intricacy than variety. In certain Arab patterns, where this ultra-elaboration of lines is employed, it appears almost as if a new principle had been introduced, but upon an analysis the designs resolve themselves into the elements with which we have already had to deal. Here, then, we have come to the end of the straight-lined family.

Why, it may be asked, can you not make a diaper on other lines, on the lines of the pentagon for example? Well, you may put together so many pentagons—and a very respectable diaper they form—especially if you further enrich the pentagons with five pointed stars. I came upon just such a diaper a little while ago, which, for the moment, promised to upset all my neatly arranged theories on the subject of pattern anatomy. I had only to dissect it to discover that it was our old friend the diamond in disguise; but so artfully made up as at first sight to deceive. There it is. It consists of pentagons put side by side, the interstices between them ingeniously filled with stars and triangles, much as the pentagons themselves are filled—so that one does not readily distinguish between the parts. You want no telling that shapes of any kind may be put together to form a pattern; but that does not alter the fact that the lines on which they are arranged, or into which they fell, must be those I have already laid down, which are indeed the base of all possible pattern.

For further variety in design, we must resort to the use of the *circle*. The circle itself must, indeed, be arranged on one or other of the foregoing plans. It must be struck, that is to say, from centers corresponding to the points of intersection of lines such as have already been described. In so far, it is only one of the innumerable arbitrary shapes that may be so arranged. But the circle is so important a feature in itself, it so entirely alters the scope of geometric pattern, that it deserves to be considered apart. One cannot simply ignore the element of curvilinear design in ornament.

Whether the idea of flowing forms first grew out of the circle is of no great consequence. It is more than probable that instinct preceded geometric principles. Many of the common flowing patterns may be deduced directly from *angular* motives. The wave, for example, is a zigzag, just blunted at the points. Soften the lines of the hexagon, and you have the ogee. Interlace straight rods, and you get waved lines, as in the common hurdle. Round the corners of the hexagon or octagon, and you arrive at a rude circle. The relation of the hexagon or octagon diaper to the diaper of circles is obvious. I take it that the bee merely works in a circle, and that the hexagonal form of the cells of the honeycomb is the result of gravitation, just as you find that cylinders crowded all become hexagonal prisms.

However, the circle itself is familiar to man from the moment he first sees the sun or moon as a disk in the sky, just as the principle of radiation is plainly perceived in the stars. For all we know, the very first pattern ever traced by man's hand may have consisted of circles. The primeval artist had only to break off a dry twig and indent the damp earth with the end of it, to get a series of round impressions which would pass for a very respectable diaper. I don't say that was so. I only mean to insist upon it that the lines on which patterns are formed can be reduced to the simplest, and that they, so to speak, force themselves upon the workman—making him, as it were, an artist in spite of himself.

The circle, with its segment, the curve, and its compound, the spiral, assumes extreme importance when we come to the consideration of the scroll (with which just now we are not concerned), but it will be seen that, even in mere diapers, it leads to an apparently new order of things.

The simplest form of circle diaper is when the circles are arranged on the square or the diamond plan, and so as to touch at the edges. By the intersection of the circles one by another an effect of much greater elaboration is at once obtained, and it makes all the difference whether you determine the proportions of the circles according to the lines on which they are struck or not. Out of the circle or its segments we get also the trefoil, quatrefoil, and all manner of cusped shapes, which also must needs be put together on one or other of the plans already propounded.

Further, out of the segments of the circle you can construct the scale pattern (which might equally have been derived from the scales of a fish or the plumage of a bird's neck). The scale may also be considered as a translation of the diamond into curved lines. Rearrange the scales, and you have a more graceful as well as a more complicated diaper—in which appears the ogee shape, once before referred to as being a curvilinear modification of the hexagon. The hexagon itself may be deduced from it. Suppose a network of interlacing wave lines or ogee shapes—it amounts to the same thing—and the result is a series of six-sided figures, very nearly approaching the straight lined hexagon. In this way the straight lined series might be derived from the curved; and so once more, by a very different road, we reach always in this maze of pattern work the same point, which is the limited variety of the skeleton on which pattern is built.

From the combination of straight lines with curved result new diaper forms, which, however, present nothing very new in the way of skeleton. You might start a scroll pattern, such as was common in the 16th or 17th century, on the lines either of the hexagon or the ogee, or a mixture of curved and straight lines, which I may call the broken ogee. And in the end it would not be very clear which of them you had taken for a ground work—or even whether you had not founded your design upon the diamond—such close kindred do those various skeleton lines betray.

I have dwelt at some length upon rudimentary diaper forms, for reasons quite apart from anything intrinsically interesting or beautiful in them, although they may be both one and the other. More especially is this likely if tender colors be employed to soften the forms, or if the color variations do not quite follow the pattern, as in the case of marble inlay, where the accidental color of the marble itself is a relief to the geometric monotony of the shapes. The Japanese sometimes go so far as to interrupt the pattern, wiping out a bit of it here and there, anticipating, indeed, the softening effect that age might impart to it.

But it is more as a *basis of design* that we have at present to consider geometric forms. The basis of all repeated patterns is, as I said, geometric—and, this being so, it is as essential that the designer should be acquainted with simple geometric principles as it is that a figure draughtsman should have some knowledge of superficial anatomy.

For all the simplicity of the skeleton lines he has to deal with, the pattern designer's art is not such a simple thing as you might suppose. He has not merely to invent pretty patterns, but patterns that can be conveniently worked—and the lines mapped out for him by the conditions of his work are, in most instances, not just those which beauty would have decreed.

They prove, however, to be identical with the lines already shown to be the basis of all recurring pattern-work—and so we begin to see that, had there been no such thing as pattern design before, and no traditional forms of design for us to follow, those very forms must have been evolved as certainly out of the more complex conditions of modern manufacture as they were out of the simple contrivances of primitive handicraft. That is to say, that the lines first given to us by the primary processes of netting, plaiting, and so on, would equally have been prescribed by the printing roller or the power loom.

It is one of the most interesting points in the analysis of pattern design to see how regularly we work round, again and again, to identically the same shapes. You cannot safely dogmatize as to the origin of this or that pattern, there are always so many ways in which it might have been suggested. Put side by side a series of waved lines so that their curves are opposed, and the effect is exactly the same as though you had opened out an ogee diaper; you can deduce either pattern from the other. Or again, if the ogees interlace, it is impossible to say whether this was the outcome of the ogee, or of waved lines, or simply of the process of netting. To take another instance of a very different kind, you know how common it is to see a waved line with leaves alternating on each side of it. It appears, on the face of it, a quite mechanical and arbitrary arrangement. But you have only to note, in nature, how the alternate leaves on a slender stem pull it out of the straight to see the natural and inevitable origin of the idea. By merely exaggerating the slight wave of the natural stem, you get one of the most conventional of ornamental borders.

So it would seem that, whether you begin with mechanical construction or with nature, it works round, in the hands of an ornamentist, to the same thing in the end—only in the hands of an ornamentist.

But this is something of a digression. I will just show you how in block printing, for example, which strikes me as presenting comparatively few limitations, the lines of all, or nearly all, possible design are laid down for us, and indeed might be deduced from the conditions of printing.

In the first place, it is of the utmost convenience, if not of absolute necessity, that the printer's block should be rectangular. We have thus, for the base of our operations, a parallelogram of more or less arbitrary proportions. For instance, English paper hangings are invariably twenty-one inches wide, and, as a block of greater length than that would be unwieldy, we are restricted to a square of 21 inches by 21 inches.

The block might represent a fraction only of the design, which may theoretically be made up of as many blocks as you please. But in practice the expense of such a proceeding would make the paper hangings cost more than paper hangings are ordinarily worth. And apart from the commercial considerations, which would be enough to prevent that kind of extravagance, it is contrary to craftsmanship so to misapply labor. The most capable artist is he who can apply his art to most purpose, and get full value out of his materials.

As a matter of fact, the wall paper designer has to content himself, then, except in very few instances, with a repeat of at most 21 inches square. Within those limits he is comparatively free. But, as I have already shown, do what he will, his repeated pattern *will* fall into geometric lines, if only those of the parallelogram on which it is built. It is just so with designers for other manufactures. The cretonne printer allows you a smaller square, and the carpet weaver a larger one—that is all. The possible lines of pattern construction are, therefore, not always and in every case possible.

In fact, we have ordinarily to consider those lines in relation to the rectangular figure which is the repeat determined for us by the conditions of nearly all manufacture. The Oriental mind, delighting in geometric intricacy, has availed itself largely of the triangular unit, and has built up with it all manner of delightfully elaborate patterns. The modern European finds it more convenient to him to adopt the simpler parallelogram. He may now and then use hexagonal or other many sided tiles, but he prefers the square. So also the weaver's cards are inevitably in the shape of parallelograms, and the printer's blocks. And though the printer makes use of the roller instead of the block, the conditions of design remain unaltered; for the roller is, for all practical purposes of design, only a block bent round in the shape of a cylinder.

Another consideration of practical design is that, for reasons both of manufacture and commerce, it is found convenient to adopt certain fixed dimensions for the tile, block, roller, or whatever it may be—and we are thus constrained to design tiles (if they are to be of any use) on the accepted three, six, or eight inch scale; textiles to a width fixed by the loom, and a length controlled by the consideration of economy; block printed fabrics under very similar conditions; and roller printed to a length as well as a width prescribed.

It would be out of place to go more fully into the various technical reasons for these limitations in design. The practical convenience of them, however, is patent. It is as desirable that the architect, for example, should know what sized tiles may be available, as that he should be able to reckon upon the "bond" of his brickwork; and it is equally clear that without some uniformity in the width of materials (such as silks, velvets, carpets, chintzes, and so on), it would be difficult to estimate off-hand the relative cost of each. As it is, the public is sometimes misled in that way. The difference between eighteen and twenty-one inches in width is not so apparent to the eye that the purchaser of a French wall paper need realize, when he selects it, that it is actually nearly seventeen per cent. dearer than an English paper nominally at the same price!

To return to the subject. The upshot of it is, that the designer has habitually to shape his design according to a rectangular plan, and that of limited, if not fixed, dimensions.

It becomes, then, a very serious question with him how far he can avail himself of any other basis. And it would be interesting to tabulate the possibilities in the way of adapting the various units of repeat to repetition within the square. It would then be seen that, though all things are possible, there are many plans the artist would like to adopt which, in order to be brought into the repeat permitted, would need to be reduced to so small a scale as to be too insignificant for any useful purpose.

One instance I may give. Suppose a square block of 21 inches, and you wish to adapt an hexagonal design

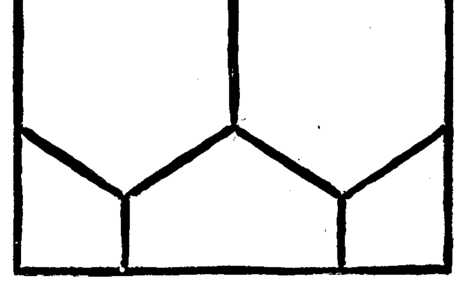


FIG. 1.

to it. Have you any notion how small the hexagons would come? If you made your hexagons 10½ inches wide, so as to get two in the width, they would not come true in the length; they would be too long (Fig. 1). If you made them true, they would not fill the square, but only a space about 21 inches by 18 (Fig. 2).

Three and a half hexagons in the width would work,

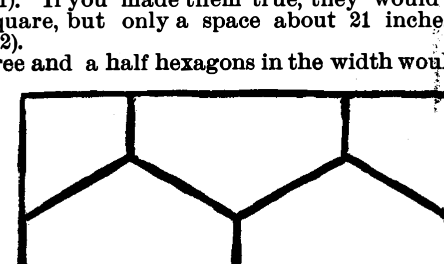


FIG. 2.

but only as a "drop" pattern. That would give hexagons of six inches across (Fig. 3). In order to occupy the square with true hexagons repeating without a "drop," they would need to be reduced to half that size; that is to say, there would have to be seven hexagons to the width, measuring each only three inches across (Fig. 4).

I have worked this out in diagram form, in order that you may more distinctly realize how strictly the artist

is bound by considerations which scarcely occur to the uninitiated, considerations which have always had a great deal to do with the design of pattern work. Fashion has had her say in the matter, no doubt—it is a wicked way she has; but though certain lines have been generally adopted at certain periods and in certain countries, I think it will invariably be found that there was some technical, practical reason for their adoption in the first instance.

Out of the conditions of weaving came, for example, the adoption of upright patterns and cross coloring (as on the silks of Byzantine, Sicilian, and early Italian design), as well as the turning over of the design on the two sides of an upright stem, or purely imaginary central line.

All things considered, the most useful skeleton to work upon is the diamond. It is on the basis of the diamond that "drop" patterns are most readily designed. The "drop" is a device by means of which the designer is enabled, without reducing the scale of his work, to minimize the danger of unforeseen horizontal stripes in his design—a danger which is imminent when the repeats occur always side by side on the same level. The printer's block, we will say, is a square; or the roller is its equivalent; or the cards take that form.

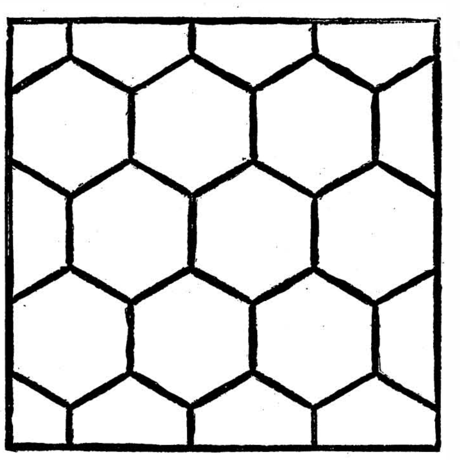


FIG. 3.

In the printed or woven strip, whether paper, cretonne, silk, or what not, the end of one repeat must tally with the beginning of the next, in order that the pattern may be continuous throughout the piece. Equally, of course, the design must be so schemed that the right side of one piece of the stuff will fit on to the left of another, and so on. But it is clear that the design may be so contrived that each succeeding breadth has to be dropped in the hanging.

If this drop is only very slight—say three inches—it would take seven breadths in a pattern of twenty-one inches deep before a given feature in the design occurred again exactly on the same level. There would be no danger then of any horizontal tendency in the lines, but, on the other hand, great likelihood of a diagonal line developing itself with even more unfortunate effect. The design steps downward, and the shorter the steps, the more noticeable is the line they take. You may see something of the sort in Fig. 5. This difficulty is avoided if you make the "drop" just one-half the depth of the pattern, so that every alternate strip is hung on the same level. Then the diagonal lines correct one another. If any line at all asserts itself, it is a zigzag (instead of a step), which, in connec-

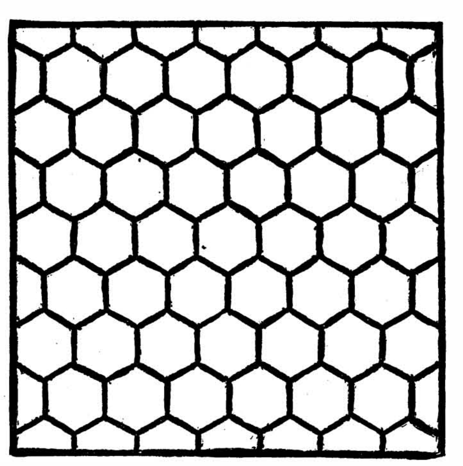


FIG. 4.

tion with corresponding zigzags above and below, may very possibly form a trellis of diamonds.

You see the zigzag resulting from a "drop" in Fig. 6.

So, you will see I had good reason for saying the diamond was a useful plan to work on, for upon it is formed the safest form of drop pattern—that, namely, which drops one-half its depth.

The designer finds it more convenient to design at once upon the diamond lines, because their simplicity enables him better to keep in view the effect of his pattern in its repeated form than any other lines (there are others) on which the drop can be worked.

I have often heard persons, more familiar with the forms of ornament than expert in practical design, complain of the difficulty they experience in scheming a "drop." If they would only think of the problem as the filling of a diamond shape, it would come very easily to them.

When the pattern within the diamond is symmetrically disposed on the two sides of a central upright line, the artist has the opportunity of working out a design which is apparently twice the width at his disposal.

If you divide your block of 21 inches thus, so that B B together equal A reversed, it amounts to the same thing as though you designed upon the basis of a squat diamond 21 inches high by 42 wide—so long, that is, as one side of the pattern is an exact reverse of the other; otherwise it would not hang. The advantage is, of course, only apparent—what is put into one strip is taken out of the other—but in the case of a pattern, appearance goes a long way. Indeed, it is difficult to overestimate the value of this expedient in design—the common property of designers for all manner of fabrics, but undreamt of in the philosophy of the ordinary amateur.

Theoretically, it is all the same whether you design a drop on the lines of the square, on the slant, or on the diamond, you may arrive in either case at identically

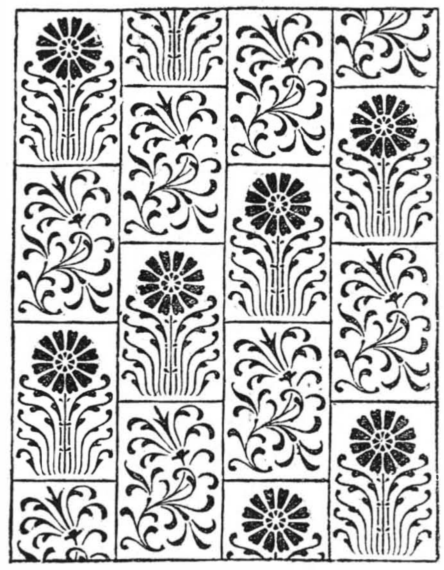


FIG. 5.

the same result. You might snip pieces from the four corners of the square, and make with them the diamond; or if you dispose them differently, you produce the oblique shape. This amounts to the same thing as though you had cut off only two corners and transposed them; but, practically, it makes all the difference in the world which plan you adopt. Your design must be influenced to a very considerable degree by the shape you set yourself to fill. It would never occur to you, for instance, to stretch a festoon or wreath across a width of space you did not see before you. So that it may be fairly said that such extension of the design beyond the width of the material is the direct result of working on the lines of the diamond. While you are designing within the lines of the square,

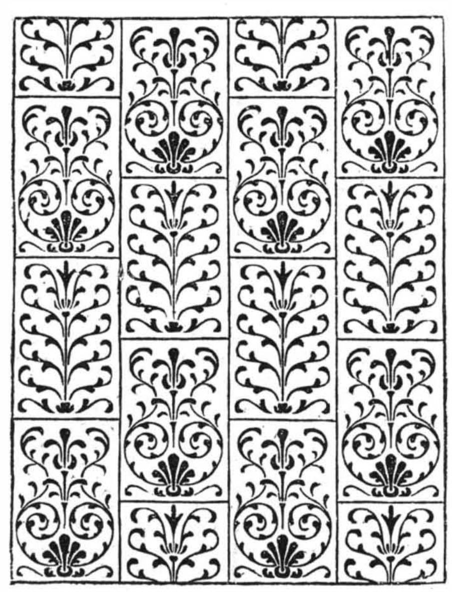


FIG. 6.

you have naturally no impulse to go beyond its limits.

Even though you have no wish to avail yourself of the full width of a block, you may still find it convenient to design within the diamond, if only in order to economize design; and, mind you, economy is an absolute necessity of the case. But for economic reasons there would be no weaving, printing, stamping, and so on; we should confine ourselves to embroidery, tapestry, painting, and other work of our own hands.

The designer, then, often begins by dividing the width of his block into halves, and so on; and by forming his diamonds on the lines thus given, obtains variety of scale.

But although, however you start, you come back always to the same few schemes, and although in any

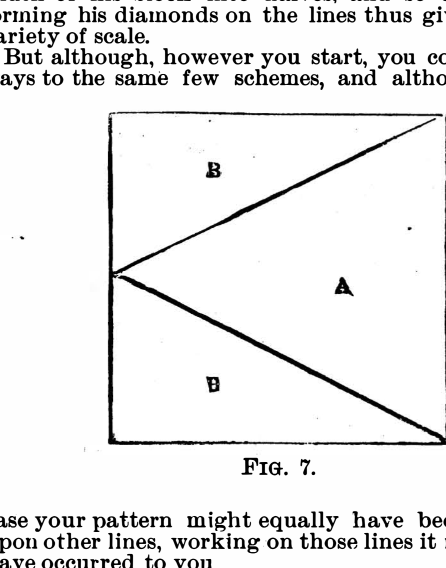


FIG. 7.

case your pattern might equally have been designed upon other lines, working on those lines it never would have occurred to you

This pomegranate pattern (Fig. 9), for example, though it *might* have been planned on the lines of the diamond, would much more likely occur to one working on the lines of the parallelogram schemed to drop.

There is this excuse, and only this excuse, for puzzling over all these varieties of skeleton.

I have shown how a pattern designed on one plan might have been (though it would not have been) designed on another plan. It is a good test of your design, if you have roughed it out on one plan, to make the finished drawing on another. By that means you see it, as it were, from two points of view—you see how it repeats without drawing much of the repeat.

Whatever the lines of the skeleton, in any important work they are usually disguised. Sometimes they are so crossed and interlaced that it is difficult to follow their intricacy. Or they may be interrupted so that you lose the thread of the design. Or, again, two or more schemes of ornament may be, so to speak, interwoven, the one asserting itself here, the other there; so that the bone-seeker is, as it were, put off the scent. Further, features may be introduced of such importance in the design that the eye is drawn to them, and fails to perceive the geometric connection between them.

Obviously, however, the most effective way of disguising the skeleton is to clothe it, as nature does, and the most natural way of doing this is with something in the nature of foliation, beneath which the bare constructional lines are as little noticeable as the stiff branches under their burden of leaf and blossom. By this means, you get at once life, interest, and variety so

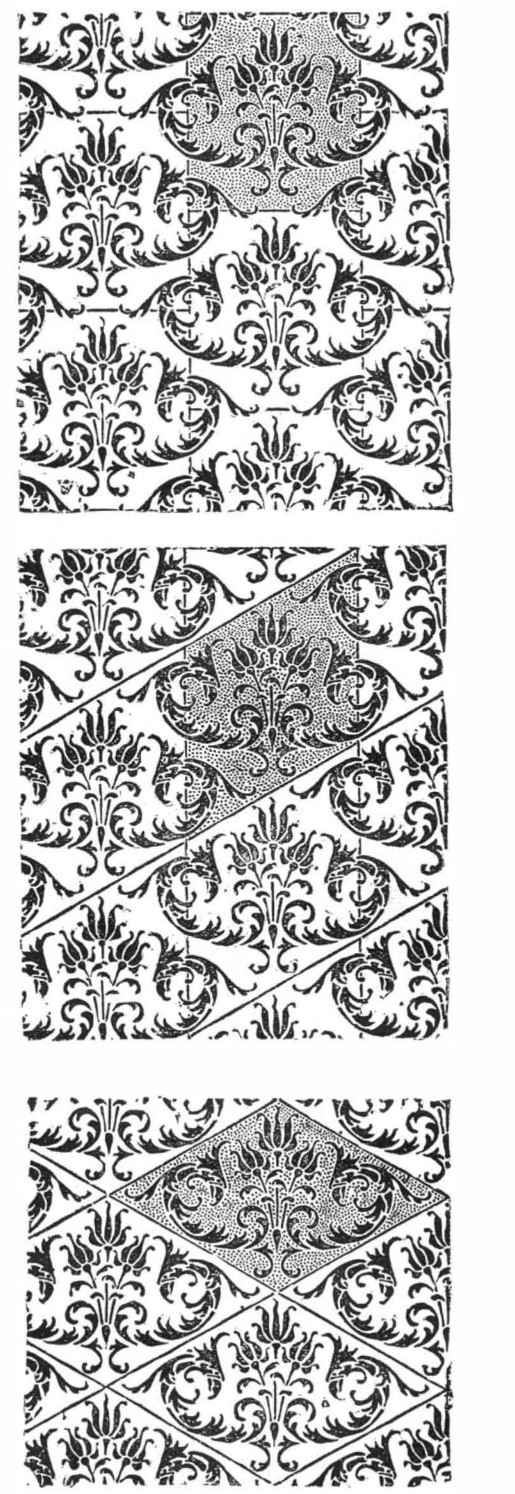


FIG. 8.

great that I doubt whether, even after this lengthy explanation on my part, you will all of you quite believe in the absolute simplicity of the skeleton forms underlying all pattern.

The foliated scroll (as you see it, for example, in Roman or Renaissance Arabesque) looks almost as though it were impossible of geometric construction—and, of course, it is never mathematically built up. But, for all that, it falls into the familiar lines. The spiral itself is only a series of segments of circles; and if you dissect any repeated scroll pattern, you will find most likely that its backbone is a wave line or spiral—certainly you will find it *has* a backbone—pattern is a vertebrate thing, and in a scroll the spinal cord is very decidedly pronounced. You can easily see when a scroll is broken-backed. It is only by experience that a designer learns to know what may and what may not be done within given lines. Many a notion which one had a thought of adopting turns out to be practically quite unamenable to the conditions.

You cannot draw a bold, flowing scroll without considerable allowance in the way of length in the blocks, cards, or whatever it may be; nor can you well avoid a certain upright tendency in patterns where the width is very much restricted. The fact of the matter is, the characteristic lines of time-honored patterns are mainly the direct result of the conditions under which the craftsman was working.

It was in some degree owing to the facility with which triangular cubes of tile could be manipulated that

the peculiarly Eastern form of geometric ornament arose. So also with us, the proportions of the square tile have resulted in a distinctly characteristic form of ornament.

I do not pretend to say whether the turning over of the design which prevails in early silks was suggested by the fact that the turning over could be so readily done in weaving; but it looks, at all events, as though the Sicilians adopted that plan of design because by means of it they could at once double the scale of their pattern. The weaver of our own day adopts it on the simple economic grounds that one set of cards does thus for the two sides of the design. It has been said that the idea of reversing a pattern owes its origin to the circumstance that you may double a sheet of paper, and so, with one action, cut out the two sides of it. If that is not so, it well might be—except that probably reversed patterns were common long before paper was. What can be done with folded paper can be done, however, with two or more *planks*, which can thus be fretted by one action of the saw—a practice out of which a distinctly characteristic form of Swiss timber ornamentation arose. Bands or stripes of different colors are so common in Eastern curtains, blankets, etc., because they can be so easily woven. Even in more elaborate silk and other designs, certain of the colors are very often distributed band-wise. The variety of color so obtained is obviously due to the ease with which the weaver can change his shuttle.

In Sicilian and early Italian silk fabrics (it is from Sicily that the art of silk weaving was introduced into Italy), both the turning over of the pattern and the banded arrangement of the color are very frequent, indeed, so much so as to form quite marked features in the design of the eleventh and following centuries. Designers would be the more ready to adopt such a plan, in that the horizontal line due to it was not anyway injurious to the effect of a fabric meant to fall in folds. The dim vertical line, which was also likely to occur, was calculated to lose itself in the more strongly marked

FIG. 9.

verticality of the folds; and the horizontal band had an absolute value in marking the fullness of the hangings.

In flat decoration the horizontal band is less unobjectionable, and it is for that reason that so many of the wall paper patterns, borrowed or stolen from good old stuffs—by their stripes you shall know them—are altogether unsatisfactory on the wall. To me horizontal stripes always suggest the ample hanging, and seem to want the folds.

In adapting a design, then, from one material to use in another, it is not enough to copy it; it needs to be translated, which translation is not so easy, but that an artist gifted with any invention of his own will find it, on the whole, better worth while to say what it is in him to say for himself, and not go on harping on the old, old tunes, melodious though they be.

Anyway, it is puzzling enough for us all to have to design to-day under these conditions and to-morrow under those. Yet there is relief in the very variety of the efforts expected of us; and in the presence of difficulties, our ingenuity, if we have any, is excited. The more difficult the conditions, the more they provoke solution. A designer must have in him something of pugnacity; he must enjoy attacking a tough problem. A man proves himself a designer, not because he has somehow arrived at a design, but inasmuch as out of unpromising material and untoward circumstances he can shape a thing of beauty.

TREATMENT OF SEWAGE SLUDGE.

A PAPER was read recently before the Institution of Civil Engineers on "Filter Presses for the Treatment of Sewage Sludge," by Mr. William Santo Crimp, Assoc. M. Inst. C. E., F.G.S. The author observed that in breweries, sugar factories, sewage precipitation and other works, large quantities of semi-fluids, or of fluids containing various quantities of solid matter held in suspension, were produced, and it was often necessary to separate the solids from the liquids. This object might generally be attained by filtration, either natural or mechanical, or by evaporation.

In the case of sewage works, where chemicals were the agent for precipitating the solids, difficulties had arisen from the large masses of sludge to be disposed of being in a sloppy and very offensive condition. Engineers had therefore endeavored to effect a reduction in the quantity, by getting rid of as large a portion of the liquid as possible. The earliest method tried was that of exposing the sludge to the atmosphere in specially constructed filters.

At Wimbledon, filters had been constructed of screened town ashes carefully under-drained, and to further aid in the desiccation of the glutinous mass more ashes were mixed with the sludge. During the winter, however, evaporation was feeble. The author found that after exposure, between September, 1883, and March, 1884, the sludge still contained 77·5 per cent. of moisture, and was very offensive. In hot, dry weather, although the sludge dried more quickly, there was much more risk of creating a nuisance, unless the material was plowed into the ground, as at Birmingham, in its fresh condition, a method which was inapplicable in many cases. In towns of only moderate size, large areas were required for the exposure of the material, and this gave rise to a nuisance after a few days' exposure, unless the works were remote from dwellings and highways.

Machines had at various times been introduced for drying sewage by the application of heat, but as sewage sludge contained in its normal condition 90 per cent. of moisture, the cost of fuel had prohibited the use of such apparatus. Millburn's drying machine, for instance, was stated to have been tried at Oldham by the Carbon Fertilizer Company, when 1 lb. of coke evaporated 6·80 lb. of water. Thus, in order to reduce 100 tons of normal sludge to 20 tons with 50 per cent. of water, about 12 tons of fuel would be required.

The paper dealt more particularly with the filter press as now adapted to this purpose. Filter presses had been employed at Wimbledon during the last two years. The present weekly production of sewage sludge at Wimbledon was 250 tons, and this quantity was reduced by means of two of Johnson's filter presses to 50 tons of sludge cake, containing 50 per cent. of moisture, at a cost of 2s. 6d. per ton, for labor, lime, fuel, cloths, etc., to which should be added interest on the original outlay, and depreciation, equal to 1s. per ton more.

The precipitation of the matters held in suspension in the sewage was effected by lime and sulphate of alumina, the average quantity used daily being, for both pressing and precipitating, equal to 0·91 ton. It had been ascertained that the quantity of solids which would be produced, if the moisture were all evaporated, would be equal to 1 ton weekly for 1,000 persons. In the case of the metropolis, assuming the population draining to the outfalls to be 3,800,000, the amount of pressed cake produced daily, calculated upon this basis, would be 1,086 tons, or 186 tons in excess of the estimate of the royal commissioners on metropolitan sewage discharge. The actual quantity would doubtless be less in consequence of the small quantity of lime used, but, on the other hand, the road detritus must form a considerable portion of the solids in wet weather.

Taking the amount at 1,000 tons daily, the annual cost of pressing would, in the opinion of the author, amount to £45,000, exclusive of the charge on capital account. In consequence of the proximity of Wimbledon to the metropolis, where enormous quantities of stable manure were produced, some difficulty was experienced in selling the sludge, although the experiments of the author, which had been confirmed by Professor Munro, of the Royal College of Agriculture, Downton, proved that the pressed sludge was of more value than stable manure of good quality.

In the author's experiments sludge cake was tried with superphosphate and with farmyard manure, the crops grown being hay, potatoes, mangolds, cabbages, and swedes, the average production per acre being in the case of sludge cake 13 15 tons, superphosphate 12·60 tons, and farmyard manure 12·27 tons, while the unmanured plot yielded 11·72 tons. Potatoes were especially benefited by the dressing of sewage sludge.

The conclusions arrived at by the author after careful observation of the filter press during the past two years were that the machine afforded a ready solution to the question of the disposal of the sloppy mass of putrescent mud produced daily in sewage precipitation works, that the offensive and useless masses might be quickly converted into a practically inodorous manure, and that the manure was superior to ordinary farmyard manure.

WORD BLINDNESS—CLASSIFICATION OF THE FORMS OF APHASIA.*

By W. H. THOMSON, M.D., Professor of Materia Medica, University Medical College, New York; Physician to Bellevue and Roosevelt Hospitals.

ON May 1, 1884, I was called to one of my stated patients, a lady of about sixty years of age, whom I found naturally anxious about a peculiar experience which had befallen her. The previous afternoon she had taken a long ride in her carriage to Greenwood Cemetery, to visit the grave of her only son, who died three years before, of phthisis.

She said that she had enjoyed the ride, and did not feel particularly fatigued by it, but on returning home began to experience a sensation of unusual weariness. She exerted herself, however, then, before going down to dinner, to write an advertisement, to come out in the morning paper, for a servant girl. She was surprised, however, to find that for some unaccountable reason she could not word the advertisement to suit her, and after tearing up some five or six such written attempts, she was obliged to ask her sister to write the notice for her.

Soon afterward, while at the dinner table, a severe pain set in at the upper portion of the left temple, which continued to increase until it obliged her to retire to her room, and not long afterward, to bed. This pain persisted through the night, but did not prevent her from having a fair amount of sleep. She rose at her customary hour in the morning, and but for the persistence of the same pain, though in less degree than on the evening before, she would not have noticed anything unusual about herself, had it not been for the arrival, soon after breakfast, of an applicant in answer to her advertisement. Upon the girl handing her some written recommendations, the lady found herself unable to make anything out of either one of them, and had to call her sister in, who then read them without difficulty.

Soon another girl came in, and my patient experienced just the same difficulty in attempting to read her references. She said that her first thought was that something was wrong with her eyes, but on looking around the room and inspecting a number of small articles minutely she was satisfied that she could see and distinguish objects as well as ever. The moment, however, that she turned to the writing, while she knew that she could see the written characters as well as she could see worsted work, yet not a single letter conveyed any idea to her mind of its character or meaning. She thereupon took up a newspaper, and at once recognized that something peculiar had happened to her, for she was totally unable to read a word in it. The separate letters could be seen, but an indescribable blur, as she thought, rendered it all indistinguishable, whereupon I was sent for to explain the difficulty.

I was much interested, of course, in the patient's story, for nothing could have been better described or expressed in words. There was neither hesitancy nor thickness in her articulation, nor confusion in diction or thought, but, on the contrary, she detailed her case with a peculiarly good choice of terms. "What is it, doctor, that makes that newspaper so illegible to me? I see that there are words there, but I am wholly unable to tell what they are," were some of her remarks. At first I directed my questions so as to avoid increasing her alarm or excitement, and in time found that she had not experienced another symptom except the above mentioned pain and her inability to read or write.

She felt no numbness or tingling, either in the face or extremities, nor any loss of power, her grasp being the same as usual in each hand, while no difference was perceptible to her between either of the lower extremities in walking. The use of the hands for sewing, buttoning, or tying, and for holding a pencil for writing, seemed as good as ever. There was no difference observable in the vision of the two eyes, no specks, nor mists, nor colored images, no marked difference in hearing on either side, nor any other symptoms referable to the ears, and there was no dizziness whatever. The face showed no distortion, either, when the patient was speaking or laughing. Examination of the radials showed them to be hard and tortuous, and the pulse was of high tension and slightly quickened. I may remark here that a brother of the patient, a few years her senior, had a slight hemiplegic attack, with aphasia, some seven years ago, from which, however, he has quite recovered.

At my first visit I was soon obliged to desist from experimenting with my patient's inability to recognize written or printed words or figures, for the plainer this strange disability became to her by my tests, the more she was inclined to become distressed by it, and to press for an explanation, so that I feared the effects of excitement upon her cerebral circulation. At my visit the next day the pain in the temple still persisted, and was uniformly described as running along a line which corresponded to the temporo-parietal suture. Some days afterward it was noticeable that she occasionally miscalled words, of which, however, she immediately corrected herself.

On cautiously testing her again, I found that her word blindness at the end of the week was complete. The largest letters, like the heading of the New York *Herald*, and figures, were as unrecognized by her, when separately pointed out, as the smallest. With the exception, however, just mentioned, her spoken language was that of a well educated woman who had learned to express herself fluently and well.

Her recovery from this condition began in about two weeks, and progressed gradually until in three months she could both read and write, especially the latter, with tolerable facility. When she began to write again, however, it was in a very small hand, but in time she quite recovered her ordinary handwriting. Since then she has shown little or no change, except a marked increase of restlessness and impatience. She now writes all her own letters, but says that whereas she used to be a good correspondent, the task of answering letters has become very irksome. Reading, however, she finds more difficult than writing, for she can read aloud only slowly, while reading to herself, she says, soon fatigues her.

A history like this goes far to support Charcot's recent classification of aphasia into sensory and motor forms, instead of the former vague and inaccurate terms of amnesic and ataxic aphasia, because it shows a derangement of speech complete in itself and yet limited to the impressions of one special sense alone, viz., that of sight. Words reached the brain through the ear as well as ever, and therefore conversation was so perfect that the patient only accidentally learned that all language on paper was for her impossible. The eye could not "speak" a word to the consciousness. To this sensory defect of speech the term word blindness has been given.

But quite parallel to this case of sight aphasia we may have a person whose brain can see words perfectly but cannot hear words, although it can hear everything else. Examples of word deafness, indeed, are even more curious than examples of word blindness. Thus Broadbent relates the case of an intelligent and well educated patient who became speechless from a syphilitic neurosis, but who evidently could read his newspaper, as he showed by going once to the nurse, in much excitement, to point out the announcement in the paper of the failure of a firm with which he had business relations.

When asked to read aloud he complied readily, but the result was gibberish, which his defect, however, prevented him altogether from perceiving. A sentence which read, "The Odessa line is again working properly," he read, "The assoil lens a puff piff miss corres povety," and so on, reading seriously and steadily, quite unconscious of the absurdity of his utterances. When trying, also, to copy a sentence, as he wrote each letter, he *named* aloud the letters always wrongly, although he *wrote* them correctly. In this case, therefore, the sounds which the brain had been taught to *hear* as words no more reached the consciousness as words than the written forms which the brain had been taught to *see* as words were perceived as such by my patient.

That the defect in either case is something very different from amnesia or forgetfulness is proved by the fact that the *mind* has not forgotten a single word, only its equivalent "eye" or "ear" symbol, as the case may be. Why, therefore, the foreign language in which the patient with word deafness talks to himself is not recognized by him as such is because the eye

* Paper read before the Neurological Section of the New York Academy of Medicine.

being still in perfect word use, and hence the meaning of what he reads being as intelligible as ever, he does not suspect that the ear is giving him no word sound at all, so that he can neither articulate words to others nor himself recognize that the noises which he makes are not words. For it must be remembered that neither sounds nor forms make words. This is done wholly by the consciousness, and it does this out of sensory registrations in themselves specifically unlike. Thus, the sound of the word "man" is as different from the written word "man" as a strain of music differs from a painting.

Moreover, it is quite probable that modern progress has enlisted another sensory, and correspondingly distinct registry of words in brain cells related to the sense of touch in the case of the blind who are taught to read with their fingers, and therefore we can conceive of a sightless aphasic who, by the appropriate lesion in his brain, might as suddenly lose his "touch" words as "sight" words are lost in word blindness and "ear" words in word deafness.

Such instances establish, at any rate, the fact of purely sensory aphasia, or derangement of speech from damage to groups of sensory cells which have been made to store up each their own kind of impressions, which to the consciousness represent words. Unfortunately, such brain impressions cannot be made hereditary, like the sounds which animals utter, because it was none of the original business of those cells to have anything to do with speech, and their final perfection of training in word registration is the sole effect of education, quite as special in its way as that of the gustatory sense in the German wine tasters, who with a mere sip will tell at once the vintage year of more than a dozen samples of hock. However, the recent progress of the pathological anatomy of aphasia, in spite of many difficulties, enables us now to locate pretty definitely the seat of word blindness to be in lesions of the angular gyrus and its adjacent parts, or the visual center, while in word deafness we may look for signs of injury about the acoustic center in the first and second temporo-sphenoidal convolutions, or in the track of their respective conducting nerve fibers.

It is an interesting observation, which goes to prove that nerve cells are taught word language only by special effort or training, that facts of disease seem to indicate that articulate speech is a development from gesture speech, for the only explanation why aphasia is so generally associated with paralysis of the right, and not of the left, side of the body, is that the use of the right hand first for expressive gesture led to the employment of the contiguous motor centers in the left brain for the tongue, lower jaw, and face to utter sounds along with the movements of facial expression. That the corresponding centers of the right brain, however, can be taught speech equally well with those of the left brain, is proved by instances of complete loss of speech with paralysis of the left side of the body in left handed persons, a perfect example of which I had not long ago in a left handed patient of mine.

But clinical experience shows another and a much more common form of speech derangement whose characters cannot be referred to the sensory or receptive functions of the mind. One of the oftenest occurring kinds of aphasia is where the patient loses all power to address others, for he can find no words come to his lips if he attempt to talk, or to his hand if he attempt to write, and even if he try to gesticulate he frequently makes the wrong movement with head or hand to what he intended.

Yet, though he cannot address others, he still can be addressed, for he can understand all talk *to* him, and can himself use either print or writing, sometimes being even able to recognize the handwriting. In him, therefore, it is plain that the sensory mechanism of speech is intact, for he can both hear words and see words, but he cannot *use* words. The distinctive feature of this form of aphasia, therefore, is inability to work the mechanism of expression. A few words may be left to the patient's tongue, but they are mere sounds, and are often used over and over again without sense, like Broca's patient, who said *tan tan* to every question for twenty-one years.

This loss of power of expression is now properly termed motor aphasia, as it corresponds essentially to the motor or "out going" element of nerve function, just as sensory aphasia corresponds to the receptive, or in-coming, element. In distinction, therefore, from the receiving of impressions, as in listening or in reading, all mental acts connected with language which demand the putting forth of effort may be properly classed as belonging to the motor department of speech, for they show that the mind has first received the materials or sensory symbols of ideas, and constructing ideas therefrom, has then sent them forth. All *speaking*, therefore, whether by word of mouth, or by handwriting, or by a wink of the eye, is a motor act which has as distinct a motor nervous mechanism as winking itself, which can be done only by a motor nerve acting on the palpebral muscles.

It is, moreover, familiar to every one that we receive thoughts by ear or by eye much more readily and quickly than we can express them in turn to others, which shows that the two processes are distinct, and not interchangeable. So that out of any five persons receiving equally clearly just the same idea there would be found a great variety of faculty or power for expressing it afterward, while disease shows that one process may be destroyed without the other being affected.

But between these two kinds of aphasia, namely, word deafness and word blindness on the one hand, and paralysis of expression on the other, we have a puzzling series of mixed cases with most varying degrees of the symptoms of each of these two kinds. Thus, cases are recorded (Trousseau) in which the patients could not utter a word, but could write as well as ever. Here there was motor aphasia, but limited to only one mechanism of out-going speech, *i. e.*, the mouth, without affecting expression by the hand. It is curious that motor speech is sometimes intact in word blindness, even when the expression is by writing, for cases are recorded (Broadbent) of patients writing correctly while they could not read anything—not only printed characters, but what they themselves had just written.

This fact can be explained only by admitting that when one learns to write, which is long after he has learned to speak, he teaches the art of writing to new nerve cells which are different from those which ordinarily register word forms, and which, therefore, may remain in working order when the visual cells are paralyzed.

In addition to these forms of speech derangement, we have still others, the most important of which is *paraphasia*, in which the patients are constantly using wrong words, and others, again, in which entire classes of words, most commonly nouns, are lost. Some of these cases I think can be best explained by admitting a third element in speech, which would correspond to the ganglionic center of a simple nerve arc. For just as we have derangements of sense registration of words, or sensory aphasia, and derangements of expression by words, or motor aphasia, so we may have derangements of recognition of words by the consciousness, or centric aphasia. Parrot talk, for instance, has but little of the centric element in it, A higher example of the same sort of words without thought is found in our committing to memory a passage just for the sake of its words, although we have its meaning perfectly in our minds. The degree, in fact, of our recognition of the words which we use is so various on different occasions, that we speak of not realizing sometimes what we have been saying. We can therefore conceive of the mental recognition of words depending upon the vividness of the impression with which they have been registered in the nerve cells or centers nearest related to the consciousness, and which impressions in turn may fade in disease until the consciousness cannot perceive them at all, and hence cannot use them. Meanwhile the lower sensory mechanism still retains them, for if you ask these patients to repeat the words after you, or to copy by dictation, they may be able to do so quite readily. Hence, any indistinctness of the impressions on these higher speech centers would result in the consciousness often mistaking them, and thus producing paraphasia.

Losses of nouns, on the other hand, occur like Bergmann's case, who had to use a paraphrase for every noun, as for scissors, "that with which one cuts," or for window, "that through which ones sees." This interesting form of aphasia plainly suggests that language is acquired, so to speak, in successive layers of specific impressions, those classes which on account of the constitution of the mind are registered first remaining the longest, and those which are registered last fading away the soonest. For there is this fundamental difference between verbs and nouns, that verbs are subjective while nouns are objective. Now, subjective words are associated in the consciousness, from the first, with some inner experience, and hence will be much more deeply impressed than those which are rather associated with external or objective impressions. Thus the consciousness that I see, I hear, or I feel, not only long precedes the recognition of what *thing* I see, or hear, or feel, but the event itself is much more deeply impressed as an idea than the object of the event, which often does not till long afterward receive a name, and thus become a noun. Even yet, in English, the sense of touch is but imperfectly supplied with its distinctive nouns, for while we can say I see a blaze, or I hear thunder, instead of I see the appearance of a blaze, or I hear the sound of thunder, we cannot say I feel a fire, or I feel an ice, but are obliged to use some paraphrase, just as Bergmann's patient had to paraphrase every objective term. Nouns, or the names of things, therefore, are more external to the consciousness than verbs, which, instead of being the names of things, are the terms which denote events in experience, *i. e.*, either perceptions or actions. Nouns, therefore, in proportion to their objectivity, partake of the nature of pure names, like proper names, which, as every one knows, are the last words to be learned and the first to go. That words, indeed, are not learned haphazard in human speech, however they may be by parrots, but rather by classes, in obedience to mental laws (and hence, can be lost by classes), is confirmed by Ogle's observation that grammatical form is always observed by aphasics in the few words that remain to them—substantives are used in the place of substantives, verbs for verbs, numerals for numerals. Thus, a patient of Broca employed *trois* to express any number, but corrected what he said by holding out the proper number of fingers at the same time. A patient of Dr. Broadbent also possessed only one name for a locality, namely, Burlington, where she had lived as a child, and she used this when she wished to name any place whatever. Kussmaul, it is true, speaks of an agrammatic aphasia in which the parts of speech are confused, but his instances of the kind belong rather to the category of brain lesions which destroy speech by first destroying thought itself, and in which the patients can hardly be termed aphasic, any more than we can so call speechless, though not wordless, idiots.

Cases of partial, and yet specific, aphasia, like that of my patient here detailed, are interesting on account of the light which they throw upon the cerebral mechanism of speech itself. It is doubtful if the labors of generations of metaphysicians could show us how the mind acquires words, or thinks in them, with anything approaching the demonstration that is afforded by some examples of derangements of speech by disease. Thus it would scarcely have been surmised by any train of *a priori* reasoning that the faculty of speech was divisible into so many distinct elements or factors as the histories of some aphasics prove. One would as little expect an artist suddenly to lose all power of representing a man while he could still paint a horse as well as ever, as to find a person who wakes some morning with all his nouns gone, or else of a scholar who in an hour becomes as illiterate as a savage who has never seen a written or printed word. But the literature of aphasia abounds with cases which read not unlike careful experiments made for the purpose of analyzing the different mental elements of language separately, so as to enable us to reconstruct the whole with that kind of certainty which only experimental tests can afford.—*Medical Record.*

COTTON SEED OIL IN OLIVE OIL.

THE *Drogisten Zeitung* quotes a statement to the effect that olive oil is frequently adulterated with cotton seed oil, the refining of which has made such progress of late years that it is produced quite clear in color, and thus there is no longer a reddish tint to indicate its presence, which can only be proved by chemical analysis. The extent of the admixture sometimes reaches and even exceeds 75 per cent. One mode of readily testing for this adulteration is with nitric protoxide of mercury, the yellow simple basic salt of this chemical combination being employed $(2Hg_2O,NO_5,H_2O)$. About one-seventh to one-sixth of an ounce of this is dissolved in a cylindrical test glass in about one-sixth to one-fifth of an ounce of nitric acid. On this solution the oil to be tested is poured in such quantity that the test glass is about two-thirds full. The two fluids are then shaken together for five or six seconds, and the change in color is at once noticed. Cotton seed oil, when treated in this solution, becomes dark brown, or almost black; but, after a short time, the solution becomes colorless and clear. Pure olive oil has a greenish or light yellow tinge, while the solution under the layer of oil assumes a dark red or brown color. Olive oil mixed with 50 per cent. cotton seed oil assumes in this process a brick red to a brownish red tinge. A mixture of 25 per cent. makes orange yellow to red yellow. The solution of the mercurial preparations remains for the most part colorless with mixed olive oils, as well as pure cotton seed oils. Pure olive oil should never assume a reddish tinge in this test. The redder or browner it is, the more cotton seed oil does it contain. Thus, a little practice allows of a color scale being formed, by which the presence even of 5 per cent. of cotton oil may be discovered in a few seconds.

RELATIONS OF TEMPERATURE TO HEALTH IN DWELLING HOUSES.

OUR acknowledgment is due to the *Sanitarian* for the above article, published in SUPPLEMENT No. 585.

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TABLE OF CONTENTS.