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# THE

# CANADIAN MAGAZINE

# OF

# SCIENCE AND THE INDUSTRIAL ARTS,

# WITH THE

# PATENT OFFICE RECORD

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VOLUME XVII

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MONTREAL
PUBLISHED BY THE BURLAND LITHOGRAPHIC CO.
1889

# INDEX TO VOLUME XVII.

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CANADIAN MAGAZINE
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Vol. XVII. JANUARY, 1889. No. 1.

## THE OPENING OF THE PASTEUR INSTITUTE.

"We cannot refrain from expressing some regret that the encouragement of scientific research should be one of the things which they do better in France than among ourselves."

With these words, trenchant enough if heeded by those in authority on whose ears they may fall, the *Times* concludes a leader on the inauguration of the Pasteur Institute by the President of the French Republic. Such a ceremony naturally suggests two distinct points for consideration—(1) the object of the institution thus inaugurated; (2) the interest attaching to the ceremony.

The Pasteur Institute is remarkable among all others in being the best form of monument ever erected, and at the same time in its being raised during the life-time of the distinguished man of science, in whose honour and for the furtherance of whose work it was designed. That the debt which the community owes to M. Pasteur will never be paid, nor even adequately acknowledged, needs no insistance; but we may be excused if we dwell upon this point a little, for, in the multifarious and different battalions of the workers in the army of science, there may well be some whose particular work has not quite brought home to them their obligation to him.

The most remarkable characteristic of M. Pasteur's work, the one which places it on so unique a pedestal, is the fertility of its results in every direction. To have elucidated at once the causation of most forms of fermentation, and the causation of most forms of acute febrile disease (this last leading to the infinitely precious invention by Sir Joseph Lister of antiseptic surgery), is on the chemico-biological side of natural science a feat of as great abstract value and of greater immediate practical worth to the community, than any one, or even two, of the greatest epoch-making discoveries of physical science. If it were not for the lamentable consequences of the apathy, with which the British public regard science and its contributions to their health and wealth, it would be sadly amusing to read, as anyone may do in even well-founded prints, the lay opinion that M. Pasteur is but a hydrophobia curer, and possibly a slightly more successful one than McGovern, the Irish quack. The flame of popular knowledge of current science always burns most unsteadily, and any sensational wind makes it flare for a short time, and then it sinks almost extinguished. It has thus been with the most recent work of M. Pasteur; and so we find at the inauguration of the Institute the wide subject of the chemico-biology of disease processes was subordinated to the representation of the existing condition of our knowledge of the treatment of rabies.

Although, considering the national importance of the general principles of M. Pasteur's work, this preponderance of attention given to one subject may be regretted, it nevertheless must be admitted that a specific instance is more easily "understanded of the people," and may consequently more energetically drive home the wedges of scientific truth. To M. Grancher was most justly accorded the very agreeable task of expounding, in a few simple and unadorned sentences, the results of the anti-rabietic treatment of M. Pasteur. Though rabies, or hydrophobia, has always occupied such a special position in the public mind, this has not prevented the application of the general principle of public ingratitude; and we are, therefore, in no wise surprised to find that the benefactor who arose, and, at his own risk and cost, attempted to remove such an evil, should have been received with calumny and misrepresentation. The consolation afforded by the unerring verdict of time rarely comes—as in the present case it fortunately has to M. Pasteur—before the benefit-conferring Prometheus is past receiving it.

M. Pasteur has always borne the monstrous attacks made upon him with such dignity and composure, that the summary by M. Grancher of the great works suggested by him must have been an intense gratification and recompense.

Our sympathy with his pleasure is, unfortunately, alloyed with regret, that of recent years health has been denied him for the perfect enjoyment of his renown.

The announcement by M. Pasteur in 1885 (the year of the epidemic of rabies in London), that he had not only succeeded in rendering dogs refractory to rabies by means of prophylactic inoculations, but had also with the same material attempted, and apparently successfully, the curative treatment of two human beings, marked the commencement of a widespread application of his now fairly well-known methods.

From the first, M. Pasteur recognized the effect that such an announcement would have upon the public mind, and, in addition to forming a resolution only to treat assured cases of rabies (a resolution he had ultimately to abandon on the grounds of humanity), arranged the facts of his work in such a manner as to provide for complete statistical accuracy in his records.

By his prescience we are thus placed in possession of an overwhelming series of facts relating to persons bitten by rabid animals. He arranged those who came to him under these circumstances into three categories.

In the first (Class A) he placed persons bitten by animals indubitably proved to be rabid by the results of inoculation from the spinal cord into normal animals.

Secondly (Class B), he grouped together those cases in which the state of the animal, though not tested by experiment, was nevertheless certified to have been rabies by a veterinary surgeon.

Finally, he constructed a third order (Class C), in which were collected those cases in which, owing to escape, &c., of the dog or animal attacking, no precise information as to its condition could be obtained, but only a presumptive suspicion that it was rabid.

Before we review the figures derived from these three classes of patients, it is important to guage the character of the statistics of the general mortality from the disease with which they have to be compared. It is only since special attention has been drawn to rabies through M. Pasteur's work, that trustworthy statistics have been forthcoming. In former years estimates of various kinds were from time to time prepared, but, while some authors took only cases of the most virulent kind, and consequently obtained exceedingly high death-rates among those bitten, others accumulated large numbers of instances, the details of which were most imperfectly ascertained, and the mortality percentages thus deduced consequently utterly untrustworthy. The severest test that could be conceived for genuine criticism of M. Pasteur's method is obviously the comparison of the death-rate in his Class A, with that among persons, not his patients, proved to have been bitten by rabid dogs by the fact of at least one of those attacked by the animal dying of the disease. Such a comparison is now fortunately possible. The probability of rabies following the bite of a rabid dog is now definitely ascertained to be from 15 to 16 per cent. of those attacked.

Now the death-rate in M. Pasteur's Class C is no more than 1·36 per cent, even including every fatal case—that is, inclusive of those persons who develop the disease during the first fifteen days after the bite. The rigid comparison of these two death-rates may well afford M. Pasteur the satisfaction of feeling that he has saved a number (to be counted by hundreds rather than tens) of his fellow-creatures from the most agonizing of deaths, and an enormous number from the worst of apprehensions.

For general biological science the next most interesting statistics are those which seem to reveal the mode of action of the curvative and prophylactic inoculations. M. Pasteur's explanations of the beneficial effects of the material inoculated was, that the nerve-tissue contained not only the microbes, the causative factors of the disease, but also their metabolic products, and that these latter by accumulation inhabit the growth and spread of the organisms. If, therefore, these products were injected into the blood-stream in sufficient quantity, he believed that the animal so treated would be protected from the malady. In this country Dr. Wooldridge had already proved, experimentally, the occurrence of such a process in the case of anthrax or splenic fever. Now, the accumulated experience of M. Pasteur's laboratory goes very far to establish this theory for rabies also. Thus, in Russia, where rabies is frightfully prevalent by reason of its being endemic among wild (wolves notably) as well as among domestic animals; the figures obtained from the respective inoculation stations are most striking:—

| | Odessa death-rate per cent. | Moscow death-rate per cent. | Warsaw death-rate per cent. |
|---|---|---|---|
| 1886. | | | |
| "Traitement simple" (*i.e.*, small quantities injected) | 3·39 | 8·40 | 3 |
| 1888. | | | |
| "Traitement intensif" (*i.e.*, large quantities injected) | 0·64 | 1·60 | 0* |

It is abundantly evident, from these figures, that successful protection is due to the energy and frequency with which inoculations are practised, or, in other words, to the quantity of protective material injected. While we cannot too heartily congratulate M. Pasteur on his triumph in finding a cure for this miserable disease, we feel very glad that, since his work has established the true nature of rabies and its mode of propagation among animals and men, the French authorities have at last awakened to the fact that there is no disease which can be more successfully prevented by legislation. M. Grancher exhibited a chart showing the immediate effect of preventive legislation in reducing the prevalence of the malady in the Department of the Seine. For us, our own experience of the measures whereby the disease was temporarily extirpated from London (though now, of course, reappearing since the relaxation of the restrictions) is so strong that we hope this additional evidence will induce our Privy Council to apply such measures throughout the country; and having thus stamped out the disease in England, prevent by suitable contra-importation measures the re-introduction of the disease.

So much for the work of the Institute as immediately in operation. The special interest of the inauguration ceremony is noteworthy. We have already referred to it as being in part due to the personal monument it establishes to the genius of M. Pasteur, but it has a more particular interest for British national science. It lies in the fact that here we see an institution erected for the national purpose of scientific investigation into the causes of diseases and their mode of prevention. We see, moreover, the head of the Executive Government, in company with the members of his Cabinet, personally giving to the movement his cordial interest and support. It must make us all wonder when our Government will cease to regard the social and political importance of scientific investigations with other than an absolutely ineffective interest.

At present, for scientific investigations of this kind, this country and its Government are positively dependent upon the charity of a private laboratory, that of the Brown Institution, the income of which, utterly inadequate, is very imperfectly helped by the defrayal, on the part of the Government, of simply the immediate expenses of the work done for them. And at the same time we wonder when our Government will remove the disgraceful legislative hindrances to British scientific work. Finally, we may ask—When shall we see the scientific millennium of an English Ministry taking an immediately personal interest in the welfare and support of such an institution? We can only conclude in the spirit of the words of the *Times* with which this article begins; and hope that, if it is generally appreciated how the lead has been taken from this country by France, at least an effort will be made by those who are responsible for the discredit thus forced on us to remove the blot by organizing a somewhat similar institution in England.—*Nature.*

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* "Intensif" treatment for last sixteen months—no death.

## RECENT ASTRONOMICAL WORK AT THE LICK OBSERVATORY.

The Lick Observatory was transferred to the Regents of the University of California on June 1, 1888, and has, therefore been in active operation as a State institution for about four months. Much of this time has been devoted by astronomers to studying the instruments under their charge and determining the constants necessary for future work, the great telescope naturally claiming the largest share of attention ; but many observations of important phenomena have been made, and the objects of greatest interest in the sky have been carefully examined with a view to the discovery of new features, as well as for the purpose of testing the performance of the lens.

The sun has not yet been observed with the great telescope, but it is doubtful whether any advantage can be gained here in the study of his surface by the use of a large instrument. The seeing on Mt. Hamilton is usually poor in the daytime, owing probably to the heated air of the surrounding valleys, which is rapidly cooled at night by radiation or shut in by the fogs which then pour in from the ocean. Mercury and Venus have been seen in the daytime only, and, therefore, under the same disadvantageous circumstances. There are, however, days of good seeing, when the features of these planets can be profitably studied.

The moon is a most beautiful and interesting object with the great telescope. It was photographed throughout an entire lunation in August, and the pictures then obtained are a distinct advance on all previous work in this direction. The diameter of the lunar image on the negatives is five and a quarter inches, and with the plates used the exposure required was a little less than half a second. Observations were made with the various instruments during the total lunar eclipse of July 22, and will be published in the memoirs of the National Academy of Sciences.

Mars had become too low in the west after the transfer of the observatory to be well seen. Numerous drawings were, nevertheless, made by Prof. Holden, Mr. Schaeberle, and myself, and published in the *Astronomical Journal.* The principal canals of Schiaparelli were seen, not as double, but as single, ill-defined lines ; and the continent of Libya, which according to M. Perrotin, had been submerged or did not exist during April and May, appears on the drawings in its usual shape and position. The micrometer observations of the satellites made by myself when the planet was in opposition have been published in the *Astronomical Journal.* The satellites, which appear to have been seen with great difficulty elsewhere, were bright and easy objects with the 36 inch equatorial—a fact which affords gratifying testimony as to the superiority of the instrument and the excellence of the atmospheric conditions. Phobos was seen on July 18, when its brightness was only 0·22 of that at mean opposition and one-eighth of that at the time of discovery by Prof. Hall. From the ease with which this satellite was seen in close proximity to the planet, it seems to me probable that we can observe eclipses during favorable oppositions, and determine the mean motions of the satellites with greater accuracy than is obtainable by micrometer observations.

Jupiter was frequently examined on fine nights in June and July. His surface showed a wealth of delicate detail, which would have required a much longer time to record satisfactorily than it was possible to give. A number of observations were made of curious appearances presented by the shadows of satellites in transit. The satellites themselves appear as large and well defined disks.

Saturn has not been observed since the telescope was first mounted in January. It was then a splendid object, all the wonderful details of the system shining with a brilliancy and distinctness probably never before equalled. The outlines of the rings were sharp and clear, and a fine dark line was seen close to the outer edge of the outer ring, with a dark shading extending inward toward the great black division. The gauze ring was very conspicuous.

Neptune has been observed by Prof. Holden and Mr. Schaeberle, and (with its satellite) been photographed several times.

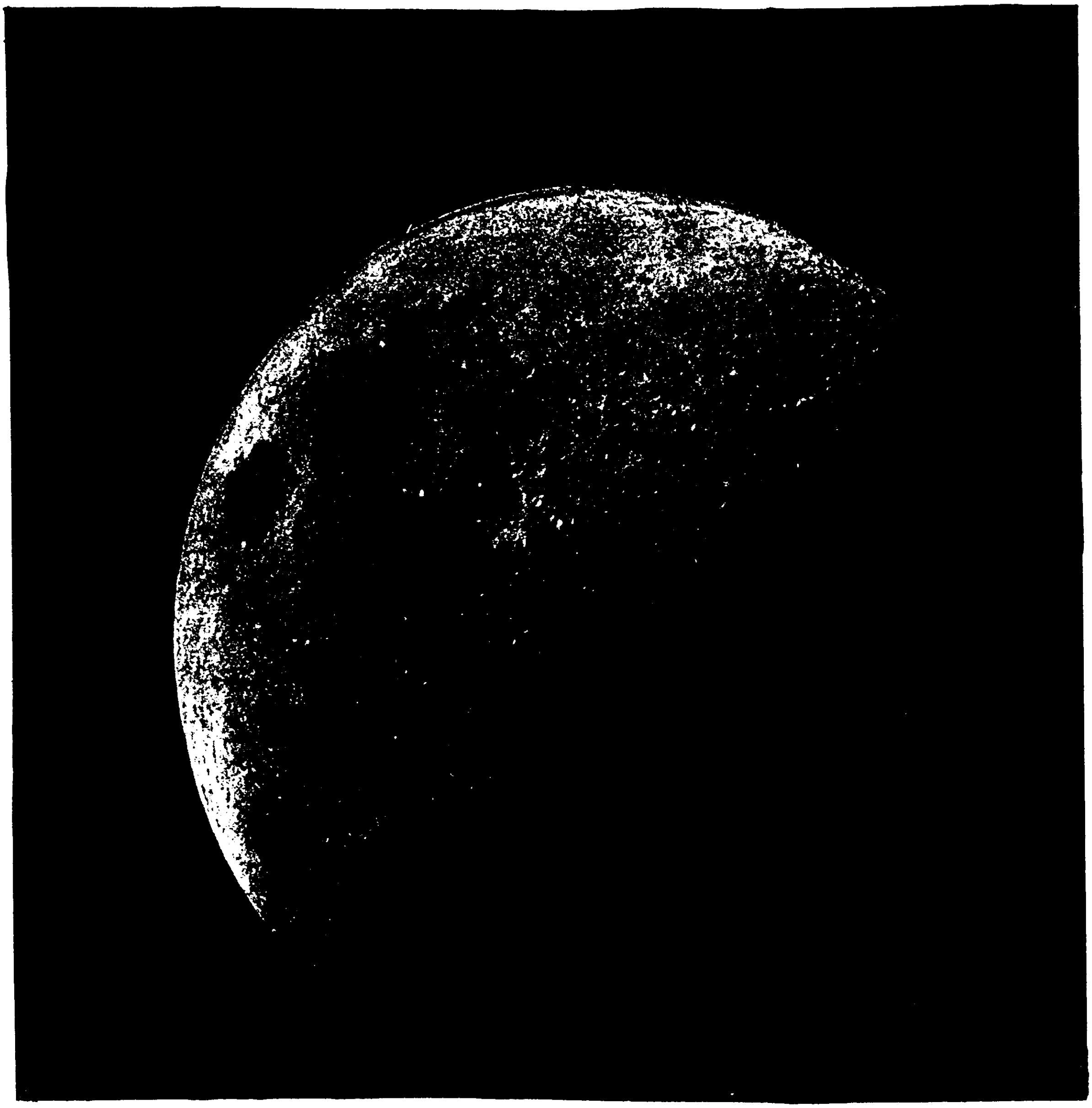
Many double stars have been discovered and measured by Mr. Burnham with the 36 inch and 12 inch equatorials. Perhaps the most interesting of this class of objects discovered with the aid of the large telescope is the star ύρ (Gamma) $\gamma$ Cassiopeæ, which is found to have a minute companion distant 2·2′′, in position angle 256°. It has been frequently observed lately with the 12 inch equatorial. Difficult stars previously known have also been measured by Mr. Burnham.

The planetary nebulæ have been studied by Prof. Holden and Mr. Schaeberle, who have observed in several of these objects curious helical forms, which do not appear in earlier drawings with smaller instruments.

The ring nebula in Lyra is a wonderful object in the great telescope. The central star discovered by Von Hahn is very conspicuous and four other stars of exceeding minuteness appear within the limits of the inner eclipse, while a star almost as bright as the one in the centre is seen exactly at the preceding extremity of the major axis of the ring. Many other small stars not so critically situated, and, therefore, less interesting, are seen in proximity to the nebula. These minute stars are beyond the range of all but the most powerful telescopes, although it may be noted that there is a class of observers with very small telescopes prepared to immediately " verify " all discoveries made by powerful instruments, even when, as has sometimes been the case, the supposed discoveries are afterwards found to be fictitious. There is no way of disproving that a difficult object can be seen by such an observer with an apparently inadequate instrument, or of showing that excess of zeal is made to take the place of sufficient optical power. Mere size, it is true, unaccompanied by other qualities, counts for but little, and the greater part of astronomical work has been done by skilled observers with instruments of moderate dimensions. To many persons the cost and difficulty of construction of great telescopes seems out of proportion to the optical advantage gained, but the same thing is seen in other departments of astronomy, as well as outside of the science. A sextant, with which the places of stars can be determined to within a fraction of a minute of arc, costs less than a hundred dollars, while thousands must be expended if fractions of seconds are to be taken into account, the error of position in either case being beyond detection with the unassisted eye.

The 12 inch telescope has been used by Mr. Barnard for the observation of comets and nebulæ. It has been found by him to be capable of giving photographic images of exquisite sharpness, and in this capacity forms an important addition to the outfit of the observatory. Twenty-five new nebulæ have been discovered by Mr. Barnard with this telescope, and a comet (comet *e* 1888) was discovered by the same observer with the 4 inch comet seeker on September 2. It is probable that the 12 inch telescope will be fitted with a new driving clock, in order to better fit it for photographic work.

No change has been made in the dome and hydraulic elevating floor of the large telescope. The convenience, and, indeed, necessity of the elevating floor is every day more apparent. The rapid motion of the eye end of the telescope (a foot in eight minutes for an equatorial star) would alone make the use of an

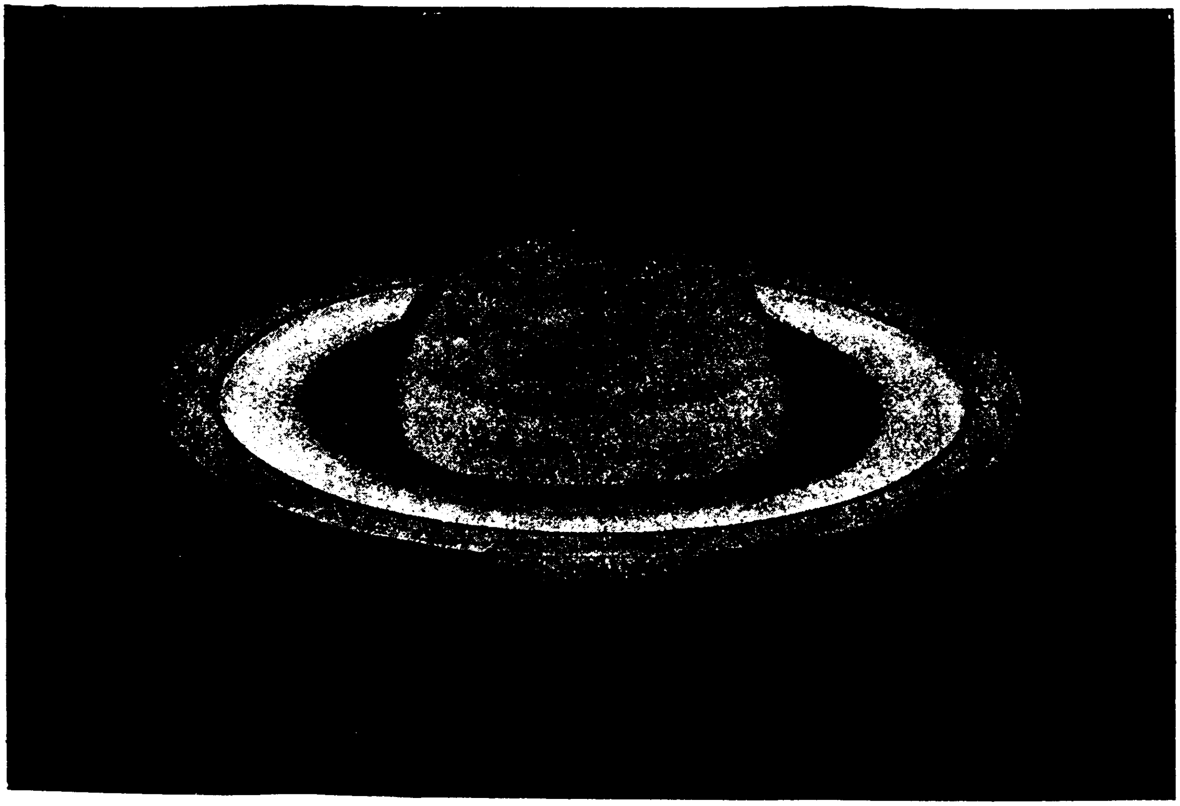


PHOTOGRAPH OF THE MOON, TAKEN WITH THE 36 INCH REFRACTOR

observing ladder proportioned to the size of the instrument extremely troublesome. The pier, when finally placed exactly in position, will probably be filled with brick and sand.

The driving clock of the large telescope was provided by the makers with an electric control, for keeping its rate in exact coincidence with that of a standard astronomical clock. The vertical shaft of the governor rotates in one second, and has near the bottom a small projecting pin. A stud on the end of the armature lever of an electromagnet is struck by the pin as the governor-shaft rotates, when a current is passing through the magnet; but when the current is broken once a second by a standard clock, the stud is withdrawn at the proper instant to allow the pin to pass. There is also an ingenious and beautifully constructed attachment for breaking the circuit in case the standard clock should, either by accident or design, omit one or more seconds in a minute. The driving clock is adjusted to run a little fast, and is continually checked by the control, the governor being allowed to rotate by turning in a friction collar. It was found, however, that the impact of the pin on the governor shaft against the stud of the armature caused a shock which was transmitted to the telescope and produced a disturbance of the image fatal to photographic work. The control was therefore removed, and another, which I devised for the purpose of giving a perfectly smooth motion, was substituted for it. The new control answers its purpose so well, and is of such extreme simplicity, that I shall give a description of it here, as it can be applied to any clockwork having a shaft which rotates in an integral part of a second.

A soft iron sector subtending an angle of 36°, and having a radius of six inches, is clamped to the vertical axis of the governor, and rotates in a horizontal plane. The sector passes very close to the poles of an electromagnet (part of the old



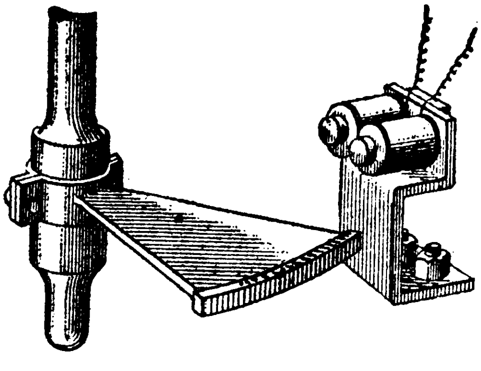
APPEARANCE OF SATURN AS OBSERVED IN JANUARY. 1888.

control) which is mounted on a slightly elastic standard of steel. At every second a strong current is sent through the coils of this magnet by means of a standard clock, the circuit being closed, as in the case of the old control, by the relay points of the chronograph attached to the driving clock. The driving clock is set so as to run a little too fast, and when the governor is started the sector gradually gains upon the click of the chronograph until it reaches the magnet of the control, when the friction produced by the attraction of the latter prevents any further acceleration, and the governor will rotate in exactly one second by the standard clock as long as the control is in operation.

The elasticity of the support on which the electromagnet is mounted plays an important part in the proper working of the control. When the sector passes at the exact instant of the passage of the current, the magnet springs in toward the sector and comes in actual contact with it, very greatly increasing the friction, while the passage of the sector at any other instant meets with no resistance, the magnet being slightly withdrawn by its support.

The current used with the control is obtained from the battery of twenty gravity cells, employed during the daytime in transmitting time signals to San Jose. As the signals are not sent at night, the battery is then connected with the control by turning a switch. With this control no shock is communicated to the telescope, and the image of a star is steady.

Since, however, changes of refraction and slight irregularities in the clockwork produce small displacements of the image in a telescope, it has always been necessary in photographing with long exposures to keep the telescope pointed by hand, correcting any displacement which may occur by the slow motions of the instrument. It was found impracticable to move the immense mass of the Lick telescope with the quickness and delicacy required in this operation, and after various experiments, Mr. Schaeberle suggested that the photographic plate should be mounted upon double slides, one moving in right ascension and the other in declination, and should be kept upon a star by means of a diagonal microscope attached to the plate. A rough experimental model was constructed on this plan by the observatory machinist, and performed so satisfactorily that a plate holder of more accurate workmanship will be made on the same principle.



ELECTRIC CONTROL OF THE GREAT TELESCOPE.

The public receptions on Saturday evenings interfere greatly with these experiments, as all apparatus must then be removed to fit the telescope for visual observation. Probably few visitors are aware of the hindrance to astronomical work caused by their entertainment, although as a duty to the public, the sacrifice is always cheerfully made. Many fine nights are to be expected during the months of October and November, but after that fog and rain will almost put an end to observation until the succeeding spring.—By JAMES E. KEELER in *Scientific American.*

## ONE MILLION DOLLAR TELESCOPE.

The chances are that the moon will be as well known to the inhabitants of the civilized world as the interior of Africa is at the present time. The telescope manufactured by order of the late millionaire, Lick, for the university known by his name in California has enjoyed the distinction of being the largest and strongest in the world, but it is likely to undergo a comparative eclipse. Mr. Abram Clark, who made it, has undertaken the task of making one yet larger and more powerful. Should he succeed, as he is perfectly confident that he will, valuable additions may be expected to be made to our knowledge of the worlds by which we are surrounded. In a recent talk on the subject, Mr. Clark disclosed some facts quite contrary to general belief in regard to astronomy. It has been popularly supposed that we had reached the maximum of effective telescopes.

The big ones, the leading astronomers told us, disclose little of the heavens' wonders. And they pointed out that the most important discoveries of the present century had been made by telescopes of a medium size. Hence the deduction, that it was uselsss to bother with larger lenses. Such a theory, of course, gave us little of practical value to hope for from astronomy. With the telescopes now in use we could expect to determine more accurately the distance from the earth to the sun, or to lay bare more stars. But in discoveries of this kind the great mass of humanity could scarcely be expected to take any very great interest. It was the verdict of most of the professionals that the Lick telescope would be a failure, so far as adding anything to practical knowledge of the heavenly spheres was concerned; but in this, as in many other instances, they were mistaken. It has already been demonstrated that, properly constructed and located, a big telescope is more effective than one of smaller size. It has been shown, in fact, that there is practically no limit to the power of a telescope, and that if a sufficiently powerful one can be made, we can bring most of the planets near enough to examine their every nook and corner.

The lens of the new instrument for the university at Los Angeles is to be 40 inches diameter, and Mr. Clark claims that he is able to make one five feet in diameter—one which will bring the moon within a few thousand feet of the earth. It is simply a question of time and money—mainly money—as a telescope with a five foot lens, properly mounted, would cost a million dollars. If Mr. Clark's position is true, and there is every reason to believe that it is, astronomy, a science which has been practically at a stand for years, will take giant strides. There will be practically no limit to the discoveries it can make, and there should come from it some practical benefits. Each year we will know more of the heavens, and of all sciences astronomy will be changed from the slowest to the most progressive.—*Mail and Express.*

## MUD AND CONTINENTS.

The world's debt to mud is a very great one. To that much despised and unpicturesque mess of mountain detritus, ground by glaciers or worn by rain, and rolled down by rivers into seas and valleys, we owe the greatest habitable plains and cultivable prairies of the earth's surface. I don't mean merely in the sense of sedimentary deposit, raised again to the dry land by internal energies as solid rock; that, though once in some cases mud, is now recognisable mud no longer; it comes to us so disguised by pressure and heat that its own parent rivers would hardly know it for their own offspring. No, I mean mud, pure and simple; mud that still visibly confesses its mudship; mud whose essential muddiness of nature nobody can possibly deny or cavil at. Of that highly useful but not very ornamental or poetical material the great basins of the Nile, the Euphrates, the Ganges, the Indus, the Mississippi, and the Amazons are almost all still undoubtedly composed, and to that they owe their unusual fertility.

In a certain abstract and general way, to be sure, we have all been familiar with this fundamental fact any time the last fifty years—provided our years yet number half a century. But as things come home to one far more vividly, and are realised more fully in all their bearings when one sees them, as Horace says, subjected to occular demonstration, I will confess that I have never recognised the importance of mud quite so fully as during the late inundations in the North Italian lake district and the valley of the Po, where I have been spending what I will venture to call a hard-earned holiday during the last week or two, and observing on every side the immense effect of even a single autumn's rainfall and snow flood.

Locarno, near the head of the Lago Maggiore, is an admirable place for beginning the study of the land-forming action of mud and rivers. Originally, one can plainly see from the contour of the mountains as they descend into the plain, the lake formed a small bay just south of the spot where the town now stands: and into this bay the torrent of the Maggia, which flows close by, emptied its waters, heavily laden in times of spate with tons upon tons of Alpine *débris.* At the present time, however, the mud of the torrent has not only filled up all this narrow bay, but has also sent out an immense fan-shaped mass of alluvial deposit far into the body of the lake itself. The alluvial plain thus formed covers a space about two miles long by three broad, and it is daily growing under one's very eyes. The late floods have added many yards to its outer edge, and the swampy margin next the lake gets gradually reclaimed by natural means as fresh material is deposited on its banks from time to time by the roaring torrent.

As yet, the fan-shaped mud-sheet deposited by the Maggia, though it pushes out for at least a mile into the centre of the lake, has not succeeded in entirely filling up the space in front, and so cutting off the upper portion or Maggiore from the main sheet of water below it. But in time, as the mud extends further and further out into the deep water, it will finally reach the opposite bank; and then the upper end of Maggiore will consist of a separate pond, divided from the main lake below by a low and fertile alluvial plain. This upper pond itself will in time be filled in by the ever-increasing mud-banks of the Ticino, the river whose water forms the main feeder of all Maggiore, and which flows into the lake above Locarno; for the Ticino, too, has a delta of its own, which similarly extends lakeward with every freshet. At one time, indeed, the Lago Maggiore must have spread as far north as Bellinzona, some twelve miles above; but those twelve miles have now been filled in from shore to shore with the *débris* of the river, forming solid land in its older and upper portion, and marshes or swamp in the newer part as one approaches Locarno.

The western bay of the Lago Maggiore, on whose bank stand Pallanza, Stresa, and Baveno, enables one to test the correctness of these explanations by applying them to a still more advanced stage in a similar land-forming process. Into that western bay the river Toce, whose valley forms the southern approach to the Simplon Pass, empties its waters, laden with the detritus of the glaciers and torrents of the great Alpine range from Monte Rosa to the Monte Leone. Now, the Toce, like the Maggia, enters the western bay sideways ; and the fan of mud which it has deposited at its mouth has therefore at last succeeded in cutting off the end of the bay entirely from the main lake. The smaller sheet of water thus isolated is known as the Lago di Mergozzo ; and it is separated from the rest of Maggiore by a low and muddy plain, through which a sluggish river empties its waters with slow meandering into the main basin. But if, from the summit of the neighbouring Mont Orfano, you look down upon the two lakes, the greater and the lesser, you can see at once, by the continuity of the mountain outline, that they were formerly both one ; while the shallow sheet of alluvium that separates them sinks at once when seen from that height into its proper insignificance as a mere mud-bank.

The well-known view of the eastern end of the lake of Geneva from the platform at Glion still further impresses the mode of action of these torrent streams in filling up lakes with an alluvial mud-sheet. Observed from that point, it is quite clear to the most untrained eye that a long arm of the lake once extended right up the Rhone valley as far, at least, as Bex and St. Maurice, while other subsidiary lakes apparently occupied the flat bottom about Martigny and Sion. But the mass of mud brought down by the glaciers and streams on either side from the Alpine range and the Bernese Oberland has now succeeded in covering the whole of this vast arm with a flat and level mud-sheet, which on the low shore between Villeneuve and Bouveret is yearly spreading itself further into the lake with marvellous rapidity. There can be little doubt that in time the Rhone deposits will fill up the whole lake of Geneva, as the Ticino will fill up the bed of Maggiore, the Adda that of Como, the Oglio Iseo, and the Sarca Garda.

But when, from the narrow theatre of the lakes and mountains, one emerges upon the broader scene of the Lombard plain—that interminable plain of poplars and vines that stretches from Turin in one monotonous level down the valley of the endless Po to Venice and Ravenna—it comes upon one with a burst of personal realisation that this, too, is one gigantic mud-sheet ; that rivers can fill up, not only lakes and minor bays or tarns, but vast gulfs and branches of the sea as well. It is quite clear that in the beginning of the recent geological period, the skeleton (so to speak) of Upper Italy consisted only of the Alps and Apennines, while a mighty bay, almost comparable in size to the Adriatic (which is, in fact, its lower still unstilted portion) spread up to the very base of the two mountain ranges. But into this bay the rivers and torrents of the twin mountain systems brought down their mud with ceaseless activity, gradually filling it up with alluvial detritus. Step by step the rivers won upon the bay, at first, no doubt, as distinct streams, each with its own minor delta ; but at last they almost all united in the single central channel of the Po, which at present carries off the joint waters of the Ticino, the Adda, the Adige, and the Mincio. Even now, however, the Brenta and a few other Alpine streams have separate outlets ; and their mud must fill up a good deal more of the Adriatic before they succeed in joining the Po some forty or fifty miles east of its existing debouchure. But in the long line of marshes, sand-banks, and islets which spread from Venice along the coast to Comacchio and Ravenna, we see this process of gradual silting up now actually in action and daily increasing.

And what is thus taking place on a comparatively small scale before our very eyes in the Po valley, has taken place, and continues to take place, in a vastly greater way over the valleys of the Nile, the Ganges, and the Mississippi. India, for example, at the dawn of the modern period, consisted only of a vast island, the Deccan, bounded on the north by an arm of the sea, which spread from the Indian Ocean to the Bay of Bengal, and from the base of the Himalayas to the base of the Vindhyas. But the rivers which flowed from the mountains on either side have gradually filled up the whole of the intermediate sea with those vast alluvial deposits which we now know as the Ganges and Indus valleys ; while the Ganges especially is still increasing its delta and carrying huge floods of Himalayan *débris* into the Bay of Bengal with astonishing and almost incredible rapidity. The eternal hills are for ever being ground down by rain or glacier, and the material thus produced is for ever being deposited by rivers in arms of the sea to form those immense alluvial plains which are the chief seat of human population.—MR. GEORGE GRANT, in *Knowledge.*

## THE STREETS OF OUR GREAT CITIES.

To the thoughtful American, visiting Europe for the first time, nothing seems so strange as the different condition under which people lived in the cities of the past, as compared with the cities of the present. In the former, the wall of a city was an invariable accompaniment—a hard and fast line having no elasticity, so that if the population grew, as populations did grow, even in the centuries that have passed, the people could only provide for the increase by squeezing more closely together. They were not even permitted to build upon the country outside the wall, within the distance of a league, as buildings would have rendered the wall useless as a protection —the land might be cultivated, but that was all.

Even the space that was allowed for streets —passages, we should call them—was begrudged by the inhabitants, who built their houses with such projecting upper storeys, that the occupants could almost shake hands across the narrow way.

And, as for the pavement, once down, it seemed to last forever. It had but little wear and tear other than that of the foot-passenger ; there were no water or gas pipes to be placed beneath its surface, no telegraph poles to obstruct its sidewalks.

But with the cities of the present how changed. There are no walls to mark a limit to their growth, their inhabitants pride themselves upon the width of their streets, they boast of their length, while below their surface is such a network of pipes conveying water, gas and steam, and wires for the electric fluid, as would amaze the people of the past. Even their merchants, instead of living in small rooms above their places of business, seek, when the day's labor is accomplished, to get as " far from the madding crowd's ignoble strife " as possible.

But with this change, comes the great problem : How can these men of business get to and from their places of business, and their homes, with the greatest expedition to themselves and the least obstruction to others ? and how can the water and other pipes—the necessities of civilization—be placed in position and kept in repair without injury to the surface of the streets ?

In the great city of London, as most of our readers are aware, the former difficulty was sought to be overcome by the construction of the underground railway. But this required an enormous outlay. Steam was the recognized motive power ; but the steam engine requires a smoke-stack, and space above for the escape of the smoke and steam, and for this a greater depth

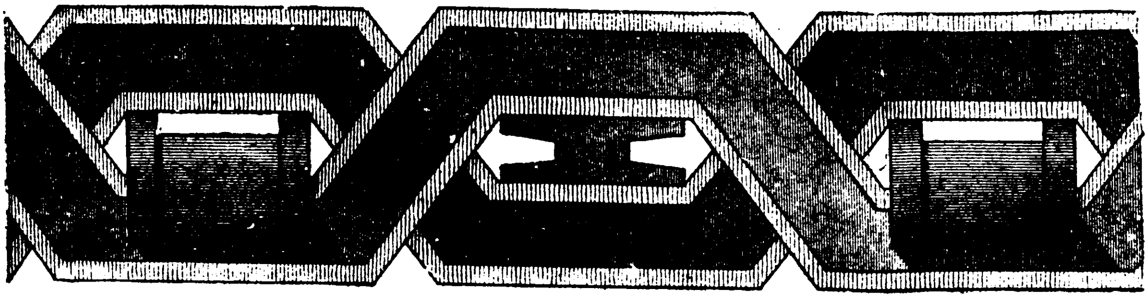


FIG. 1.—SECTION OF WOVEN DOUBLE T-IRON.

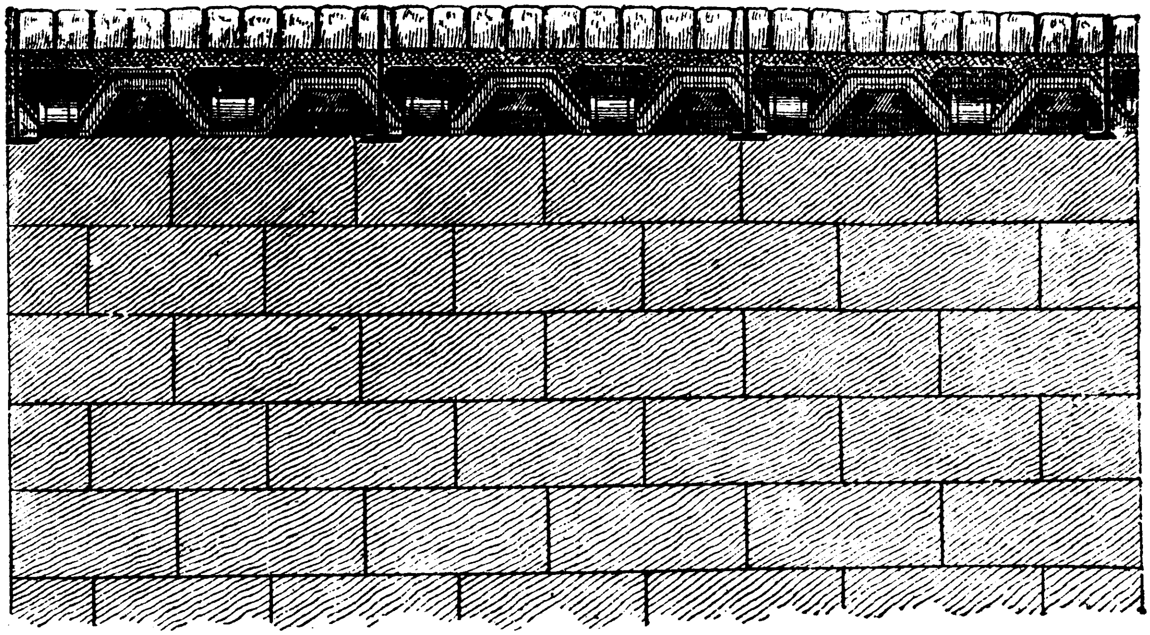


FIG. 2.—RETAINING WALL AND SECTION OF ROOFING

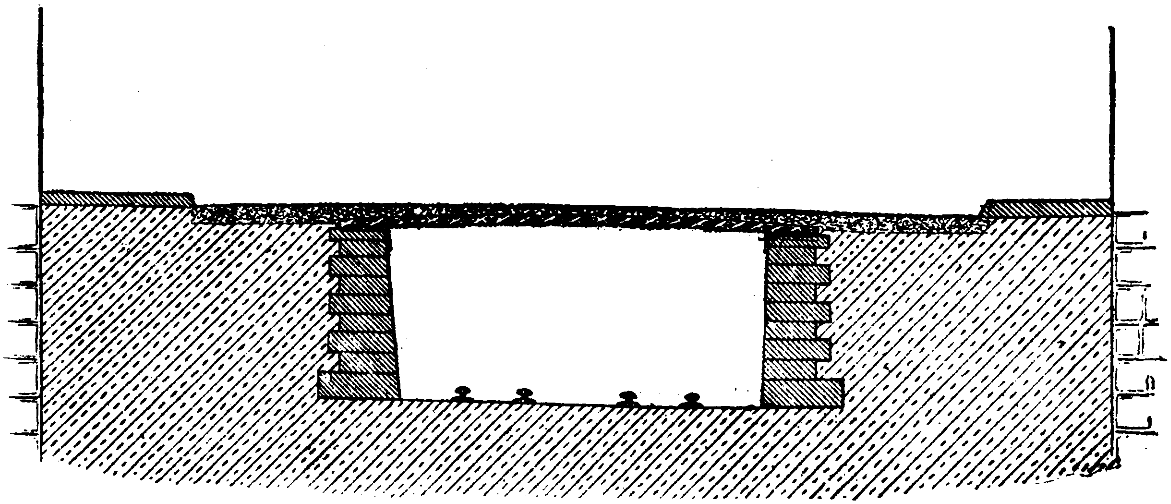


FIG. 3.—WOVEN-IRON COVERED SUNKEN RAILWAY.

of tunnel must be allowed; and as the covering of the tunnel was masonry, an increased depth was necessary to allow for its thickness, and the crown of the arch to give it strength, so that, in addition to the great cost of construction, its passengers have to ascend and descend a long flight of steps to get from the streets to the platform, or *vice versa*.

In the great city of New York, the difficulty has been sought to be overcome by the elevated railway. But this mode of travelling, while pleasant to the traveller, is destructive to the city; and, to say the least, it is noisy, dirty, confusing and an obstruction. How, then, can this difficulty be overcome? and how, concurrently can the other difficulty—namely, the keeping of the pipes and wires below the surface of the streets, without injury to their surface—be satisfactorily arranged?

With the developement of the cable, and electric motors, rendering unnecessary the steam engine and its smoke-stack, it is not necessary to make an excavation deeper than the car in which the people ride. Here, then, is one great saving in the cost of excavation; and, if we can show that a covering can be made, suitable in every way, inexpensive, firm, durable, and yet not more than ten or twelve inches thick, instead of the usual thickness of a covering of masonry, with its loss of space to gain the strength of the crown of the arch, then, we think, that the future of that mode of travelling is established; and it will not be many years before all the lines of rails will be placed below the level of the street, where both the electric motor and the cable, untrammelled by the obstructions of the street above, will be able to give full power to their speed.

And if, in addition, this mode of covering is suitable for conduits in which all pipes and wires can be placed, and in which they can be reached for repairs, without disturbing the surface of the streets, we think the future of our streets is assured, a future free from the noise and confusion of the car traffic, and with a never-broken surface for the ordinary traffic.

In our issue of October, we called the attention of our readers to an illustration of woven iron, with an accompanying description of the very simple and inexpensive means by which the weaving is effected, and the great strength of the fabric; and we propose to use this fabric, as shown on the preceding page, (Fig 1), but made perferably of double **T**-iron on account of the greater strength, for weight, that it offers.

In Fig. 2 we give a longitudinal section of a covered cutting, showing the retaining wall supporting a row of single **T**-girders, upon the flanges of which rest slabs of the woven iron, say, three or four feet wide, and of suitable length to reach across the cutting, the interstices of the fabric filled with asphalt, and, resting upon its surface, suitable paving blocks; and in Fig. 3 we give a cross-section of the same covering, minus, however, the paving blocks, but showing a smooth asphalt surface reaching from curb to curb.

We shall be glad if this subject shall receive the attention and thoughtful study of those who are able practically to judge of its merits or demerits, and are interested in solving that which has become a difficulty of the age—namely, the management of the streets of our great cities.

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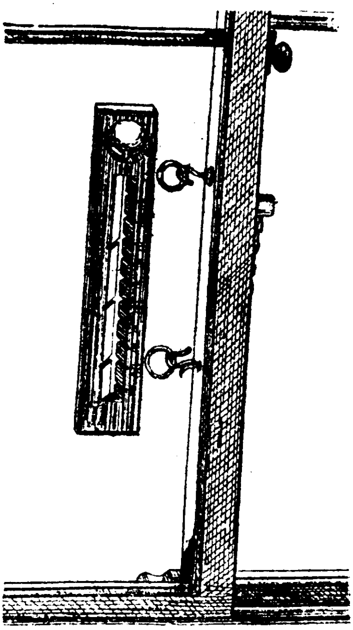
NOTE.—Should any reader wish to familiarize himself with this system of covered sunken railway, and see how small an excavation is required, he can best do so by examining the opening to the cutting in Fourth avenue and Thirty-fourth street, and also by noting that the Sixth avenue surface cars have free play between the lines of supports of the elevated railway, which are only 20 feet apart. - By HENRY D. PLIMSOLL, in *The Manufacturer and Builder*.

## MITCHELL'S MINIMUM THERMOMETER.

This thermometer is intended to be hung outside a window, so that its scale can be set by a person indoors without opening the window. It is placed so that it can be seen against the sky, and the height of the column of mercury or spirit is read by transmitted light, and not by reflected light, as in the case of thermometers hung against a wall. This greatly increases the ease with which the instrument may be read, and both sides of the bulb and tube are exposed to the air, so that they rapidly take up the temperature of the air, and the instrument is not so much affected by the heat of the wall or support on which it is hung. The tube is protected from injury by being sunk in a slit which is cut through the thermometer frame, or the block of wood to which the tube is fastened. The sides of the slit are notched at convenient intervals corresponding with the engraved scale which shows the height of the column. When the thermometer is hung so as to be seen in the morning on the background of the sky, these notches appear like stars or beads of light adjacent to the tube of the thermometer, and enable the height of the column of mercury or coloured spirit to be read from a considerable distance—for instance, by a person in bed, without getting up.



The thermometer is intended to be hung outside the glass of the window from the underside of the sash, as shown in the diagram. The hook at the bulb end is fixed in the woodwork; but the hook at the other end is attached to a chain which passes through a moderate-sized gimblet hole in the woodwork, and lies along the top of the sash inside the room. A person wishing to set the thermometer unhooks a ring at the end of the chain, which passes over a brass pin that stands up from the top of the sash, and lets down the left-hand end of the thermometer, so that the bulb is highest. The setter (which, as in the ordinary minimum thermometer, is a little pin of black glass within the tube) is made loose, and slips down by the action of gravity until it reaches the end of the column of fluid, where its further progress is checked by the surface tension of the fluid. The thermometer is then drawn up again, and the setter is left in position, so that it will be drawn backwards by the receding column of fluid, and again mark the minimum temperature registered.—*Knowledge*.

## TYPE WRITER RIBBONS.

The ever recurring query as to reinking type writer ribbons has been kindly referred to me by the editors of this journal.

In treating of this question the second time, I shall endeavor to put whatever knowledge I possess regarding it into such form as will enable any person of average skill to make an ink suitable for any particular style of ribbon and apply it. I mean to illustrate the principles involved and how to meet the various requirements. My reason for doing this, rather than to give a specific formula to be followed in every instance, is that often an experimenter has already produced an ink which lacks only some correction to make it entirely suitable; for "there are many ways leading to Rome." Besides, an ink which may have been suitable at one time may fail at another, because used under different conditions, and once a person knows how to correct a defect, the ink may be made to answer all purposes.

The constituents of an ink for type writer ribbons may be broadly divided into four elements: 1, the pigment; 2, the vehicle; 3, the corrigent; 4, the solvent. The elements will differ with the kind of ink desired, whether permanent or copying.

Permanent (Record) Ink.—Any finely divided, non-fading color may be used as the pigment, vaseline is the best vehicle, and wax the corrigent. In order to make the ribbon last a long time with one inking, as much pigment as feasible should be used. Suppose we wish to make black record ink. Take some vaseline, melt it on a slow fire or water bath, and incorporate by constant stirring as much lampblack as it will take up without becoming granular. Take from the fire and allow it to cool. The ink is now practically finished, except, if not entirely suitable on trial, it may be improved by adding the corrigent wax in small quantity. The ribbon should be charged with a very thin, evenly divided amount of ink. Hence the necessity of a solvent, in this instance a mixture of equal parts of petroleum benzine and rectified spirit of turpentine. In this mixture dissolve a sufficient amount of the solid ink by vigorous agitation to make a thin paint. Try your ink on one extremity of the ribbon; if too soft, add a little wax to make it harder; if too pale, add more coloring matter; if too hard, add more vaseline. If carefully applied to the ribbon, and the excess brushed off the result will be satisfactory.

On the same principle, other colors may be made into ink; but for delicate colors, albolene and bleached wax should be the vehicle and corrigent, respectively.

The various printing inks may be used if properly corrected. They require the addition of vaseline to make them non-drying on the ribbon, and of some wax if found too soft. Where printing inks are available, they will be found to give excellent results if thus modified, as the pigment is well milled and finely divided. Even black cosmetic may be made to answer, by the addition of some lampblack to the solution in the mixture of benzine and turpentine.

After thus having explained the principles underlying the manufacture of permanent inks, I can pass more rapidly over the subject of copying inks, which is governed by the same general rules. Personally I am not in favor of the use of copying ink: first, because the print is liable to fade, smear and become invisible; second, because it is unsuitable for legal and other documents of value; third, because it is easier to write two or more copies at one operation with manifold (carbon) paper than to make a second press copy after the writing is done.

For copying inks, aniline colors form the pigment; a mixture of about three parts of water and one part of glycerine, the vehicle; transparent soap (about one-fourth part), the corrigent; stronger alcohol (U.S.P.) (about six parts), the solvent. The desired aniline color will easily dissolve in the hot vehicle, soap will give the ink the necessary body and counteract the hygroscopic tendency of the glycerine, and in the stronger alcohol the ink will readily dissolve so that it can be applied in a finely divided state to the ribbon, where the evaporation of the alcohol will leave it in a thin film. There is little more to add. After your ink is made and tried—if too soft, add a little more soap; if too hard, a little more glycerine; if too pale, a little more pigment. Probably printer's *copying* ink can be utilized here likewise, because everyone now has the means to modify and correct it to make it answer the purpose. I have not tried it, because I am opposed to copying inks.

Users of the type writer should so set a fresh ribbon as to start at the edge nearest the operator, allowing it to run back and forth with the same adjustment until exhausted along that strip; then shift the ribbon forward the width of one letter, running until exhausted, and so on. Finally, when the whole ribbon is exhausted, the color will have been equably used up, and on re-inking, the work will appear even in color, while it will look patchy if some of the old ink has been left here and there, and fresh ink applied over it.

According to the directions here given, I have done nearly all the re-inking of my ribbons for more than seven years, and I am sure, if the reader should fail, it will be due to inattention on his part to some of the principles laid down.—Isidor Furst, in *American Druggist.*

## WHAT IS LUCK?

A philosophical definition of luck is given by an English writer as a capability of being incapable:—"The first Rothschild was probably right, from his point of view, when he said that he never would employ an unlucky man. On the other hand, the lucky man is usually the man who fits his fortunes; who, whether apparently able or stupid, can do just what his especial circumstances require him to do. Very stupid men are often ready men, armed with a readiness as of dogs when they twist from under a cartwheel unhurt. The 'fool who makes a fortune' is usually a man with just the foresight or just the judgment or the intuitive perception of the way things are going—a faculty like long sight or keen hearing, and independent of intellectual power—requisite to make large profits quickly. In fact, the fortunate man is usually the man who, in consequence of some hidden quality in his nature, deserves fortune."—*Popular Science Monthly.*

## THE USES OF THE PAPER TRADE.

The uses of a technical paper to the mechanic are multifarious. It affords him access to current news of interest to his trade, keeping him well informed respecting the latest improvements in machines and processes; it puts old things in a new dress, presenting familiar facts under such various aspects as to stimulate his thoughts with the surprise of discovering that there should be so much that he never dreamed of in what he supposed he knew all about; it explains the why and wherefore of doing this, that and t'other in his daily workshop practice, and thus, unconsciously to himself, trains him to the habit of investigation, which is the most valuable service of all. It is this discipline of the mind, derived from the habit of thinking and investigating, that fits the reading mechanic to take the lead of his fellow-workmen. It is the reading workman who makes the inventor, and to this class, whose mental training is largely obtained from the technical journals, that we owe much of the progress in the mechanic arts.—*Exchange.*

## CONCRETE.

### RANSOME'S PROCESS.

Ransome's stone has for many years borne a familiar sound to the ears of the writer. During a lifetime Mr. Frederick Ransome, the father of Mr. Ernest L. Ransome of this city, whose process I propose to deal with in this article, has given unremitting and toilsome attention, in conjunction with Mr. Ernest Ransome, his son, Mr. Henry Bessemer and other inventors, to the production of an artificial building-stone which has almost rivalled Nature herself. In London, Calcutta, Hongkong, and I may say, in the majority of British Colonial settlements, the patents of Mr. Ransome have been practically tested and for structural and decorative purposes they are unexcelled.

In 1873, Dr. Sterry Hunt, professor of geology in Boston, said before the Institute of Technology that "he had followed with the more interest the labors of Mr. Frederick Ransome, who, after years of experiment, has solved satisfactorily and completely a great industrial problem—with the more interest because he himself had carried on, in 1857–8, a series of experiments very similar in character and in chemical results, in his endeavors to find out the method by which certain soft earthy rocks, consisting in great part of silica and carbonate of lime, have become hard and crystalline." The speaker had shown by researches in the laboratory, and also by observations of limestone strata in the vicinity of eruptive rocks, that a reaction between the silica and carbonate of lime takes place in the presence of carbonate of soda, by which the alkali brought about, little by little, the solution of the silica and its union with the lime to form a hard silicate of lime. This is Nature's method. The action of alkali in dissolving the silica and then giving it up to the lime, was an example of many of the so-called actions by presence, which are really cases of chemical affinity, acting under peculiar conditions. It was reserved for Mr. Ransome, by using both the lime and the silica in their free, soluble and active forms, and by bringing in the alkali already combined with a portion of silica, to make this curious action very rapid, and to show that the product forms a cementing material which is available for binding particles of sand into hard, stonelike masses.

Here we come to the secret of the hardening of cements—the small amount of alkali used by Mr. Ransome in the process itself, united with the successive portions of silicate of lime formed, thus becoming locked in an insoluble compound, as we see every day in granite rocks. It is a generally accepted view at the present time that the hardening of hydraulic and Portland cements is in a great measure due to the transferring power of a small portion of alkali which such cements are found to contain.

The application of Fuchs' invention made nearly 70 years ago, of the adhesive compound of alkali and silica, called "water glass," was the next step in the evolution of artificial stone, Mr. Ransome making it available by the discovery of chloride of calcium as a fixing agent.

The next step was to use such materials for cement as would themselves become insoluble, and require no after-treatment with chemicals. This was effected by adding to the ingredients hydraulic lime and active silica, the silica being in time transferred through the agency of the alkali to the unsaturated base of the hydraulic lime, while soda itself unites with the silicate of lime to form an insoluble double silicate of lime and soda.

We have here a double advantage: First, the richness of the material in combined silica as an admirable addition to its resistance to atmospheric and abrading influences; and second, the acceleration of the hardening process to a few hours by the use of water glass.

As regards strength, this stone was proved to resist a crushing force of 9000 pounds to the square inch. Disks were also made of the material, which were used as millstones and grindstones. Combined with emery, the artificial stone when made into a disk for saw-sharpening would, when only one-fourth inch thick, cut a saw-blade an eighth of an inch thick at the rate of six inches per minute.

"Ransome's hydraulic cement," composed of furnace slag (which consists of silica, alumina and lime), was an outcome of the discovery made by Mr. Charles Wood, of the Tees Iron Works, who in the year 1873 obtained a patent for granulating the previous refractory slag by running it into water. The analysis of slag sand is: Silica, 38.25; alumina, 22.19; lime, 31.56; magnesia, 4.14; calcic sulphide, 2.95; and protoxide of iron, .91. An especial advantage derived from the use of slag sand in the manufacture of cements is the avoidance of the usual severe burning. It is admirably adapted for use in the construction of fireproof concrete.

The concluding portion of this article will consist of a description of the means taken and the process adopted by Mr. Ernest L. Ransome, of this city, in his concrete constructions. The discovery of the safe and effectual combination of iron and concrete has promised such great and beneficial results to the building world—the safety from fire, from rust, and its cheapness and lightness—that prejudice against, and ignorance of, its merits can have the sympathy of no intelligent man.

Mr. Ernest Ransome has taken out many patents during late years through the *Mining and Scientific Press* Patent department, and has done much to further the practical development of concrete constructions on this coast.

The first and most important desideratum in the manufacture of concrete is the securing of a proper mixing of the aggregates and Portland cement. Drawings accompany the present description of his process. In two of them we have the "mixers," which he has found most useful, and on which he has obtained patents. Without a proper machine, the work cannot be thoroughly and cheaply accomplished.

The cubical iron box in Fig. 1 of the accompanying engravings is partly filled with the cement and aggregates, the cement being of the finest quality and ground to a very fine powder so that it shall come in complete contact with every portion of sand and broken rock: 640 to the square inch is the size of the mesh which grades English Portland cements. The Germans are grinding a poorer cement even finer, and as a consequence some brands from that country are making good headway in the market.

Water is admitted to the cubical iron box through the axle; for this hollow axle Mr. Ransome secured the patent. Six of these machines are being run by steam-power for the purpose of mixing the concrete as used in the dam for the new Spring Valley reservoir. Mr. H. Schussler says that they have given the utmost satisfaction, and the writer was lately enabled to see the thorough manner in which the mixing was accomplished.

With simple horse-power, three men and a boy can turn out 1700 cubic feet in one working day. The machine can be had for hire, so that the cost of purchasing is converted into a charge of $2 per day to the hirer.

In Fig. 2 is seen an improved mixer which is so constructed that its motion is a *continuously* revolving one (the cubical box necessitates a constant opening and shutting of the door in its side for the purpose of filling and emptying it). The power is derived from a small steam engine. At the side presented toward us can be seen the scoop by means of which the ingredients are carried into the revolving wheel. Within this wheel are a series of hinged iron plates which are connected with the machinery, so that a flapping and scooping motion is constantly kept up. By a simple device the motion of these plates can be reversed so that the motion backward and forward within the revolving wheel contributes to a thorough and even mixing of the materials. These, when mixed, come out in a ready flow at the other side, ready for wheeling away for immediate use.

The machine is made of different sizes, from an output of 1000 to 15,000 cubic feet per day with from three to six men.

Mr. Ransome has given much attention to the construction of a cheap and secure pavement, arched over a cellar or otherwise, especially important in a city like San Francisco, where in many places of its business portions large cellars are much in request, and where the amount of goods recklessly piled up on the sidewalks must amount to many tons.

There are two patents for this also. In the first the arch forms the pavement, the joint being over the iron beams, the surface marked with artificial flags. In the second, there is a joint specially adapted to allow for settlement; on either side of the upper portion of the beam there is left a small space, and adjoining the girder a recess is formed in the pavement. This latter can be filled in when the pavement has settled, and as it is uniform with the marking of the pavement, it is imperceptible.

### WELL CONSTRUCTION.

In contriving a simple mold for the walling up of a well with concrete, Mr. Ransome has met a long-felt want. The cleanliness and lasting power of a well so constructed are advantages which, were the cost greater instead of less than bricks, can be appreciated by the most inexperienced.

The woodwork of the mold is so arranged that any carpenter can put it together in two days, even though it be for a reservoir 50 feet in diameter.

It will last an indefinite time, and the small amount of iron used in its construction costs less than $20. The mold of which a drawing is given, can also be changed from one size to another.

The latest patent applied for by Mr. Ransome was that of imbedded twisted iron bars in concrete. It is now an established fact, and, strange to say, a newly discovered one by Mr. Ransome, that an iron bar when twisted without heating is increased in strength upward of 30 per cent. In this last patent there is a great improvement upon Mr. Hyatt's invention, where the bars or blades were perforated at every few inches, and anchored by short rods or wires threaded through the holes, which latter would tend to weaken them—a further disadvantage being the difficulty of making it perfectly fireproof.

Mr. G. W. Percy, in a paper read before the Technical Society of the Pacific Coast, said that while Mr. Jackson's late experiments in the strength of iron and concrete were being conducted, "Mr. E. C. Ransome, also a member of this society and a very successful maker of concrete, was experimenting with a different method for the purpose of obtaining the same result.

"For several years he had used old wire cables as a band in concrete walls, the irregularity of the wire ropes, caused by the twist of the strands, preventing the possibility of slipping when imbedded in concrete. This probably suggested to his mind the idea of twisting square bars of iron or steel and imbedding them in the bottom of concrete girders or flat slabs.

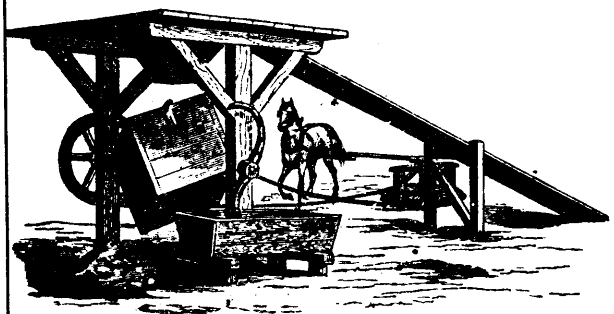


FIG. 1.—CUBICAL BOX MIXER.

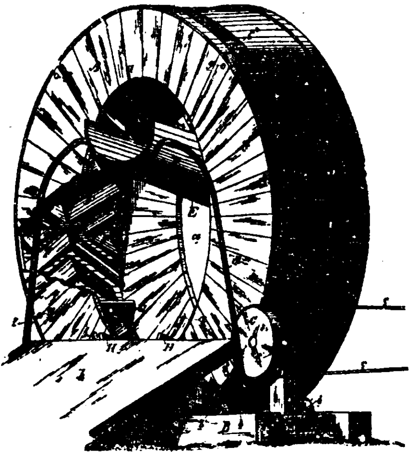


FIG. 2.—CONTINUOUS MIXER FOR CEMENT.

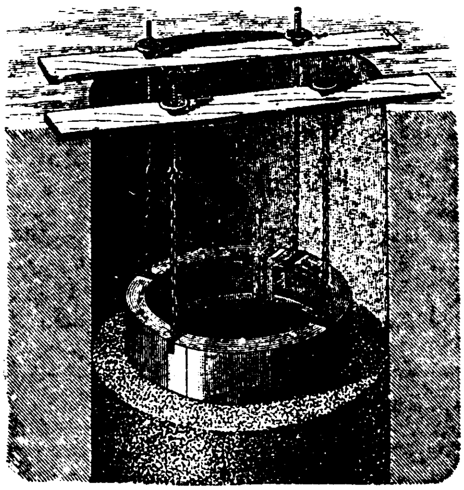


FIG. 3.—MOLD FOR CONCRETE IN WELLS.

"It was evident that this method would be a great improvement over that invented by Mr. Hyatt. The twist in the bar would cause it to be held securely at every point along its length, instead of at intervals of several inches; no metal would be lost by punching holes, and no extra iron required for anchors. The labor of twisting cold rods would be but a trifle, and the entire sectional area of the iron could be placed just where it would be most effective.

"Mr. Ransome promptly patented his improvement, and since 1885 it has been used quite extensively in this city."

For withstanding dampness, concrete is admirably adapted; for withstanding heat and fire, even better. The comparative expansion on the application of heat to iron and concrete is: For iron, .0014; for concrete, .000137, at 185°.

Iron and concrete can be used together without any ill results from the deflection of the former or the rigidity of the latter. The most intense heat has no effect in destroying that homogeneity.—*Milling and Scientific Press.*

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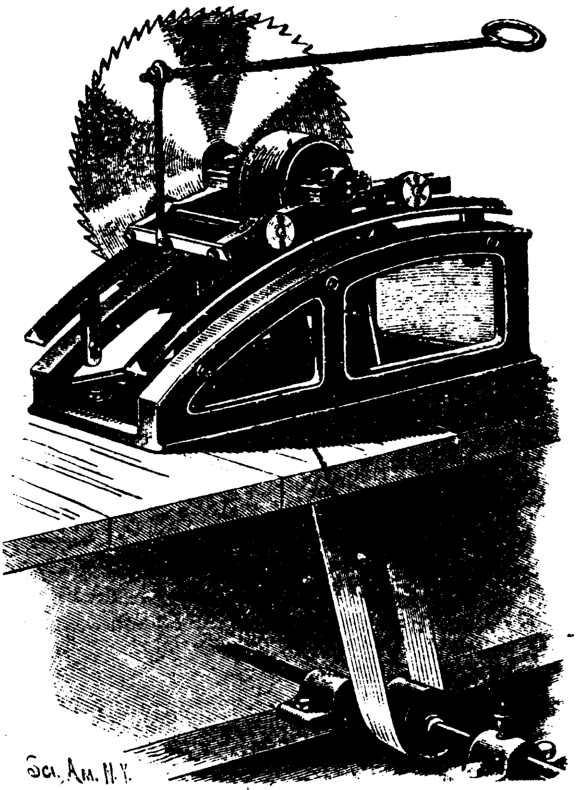
## CUT OFF SAWING MACHINE.



Cut-off Sawing Machine.

We illustrate in the cut accompanying this article an ingenious mounting for a circular saw. It has been a usual practice when such saws are used for cutting off ends of timber or of boards, and for similar work, to mount them on an arbor at the lower end of a frame, swinging pendulum fashion from the beams of the ceiling of the shop. By the present invention all upper frame-work is dispensed with. The saw works on an arbor journaled on a carriage, that moves on a stationary frame or bed plate resting on the bench, working back and forth through the arc of the circle, being controlled in its reciprocations by the operator. The belt is driven from a pulley underneath the bench, the axis of whose countershaft coincides with the centre of the arc or of the main frame. The rails on which the saw carriage moves are adjustable by bolts and slotted lugs. Their curve is also an arc of a circle, but in practice they are set slightly out of centre with the driving pulley. As the saw is drawn forward it makes its cut. The rails, therefore, are so set that the belt is tightened as the saw comes forward and is slightly loosened as it recedes. Such loosening of the belt avoids wear of belt and journals. This receding motion is performed principally by gravity, so that the operator has little more to do than to pull the saw forward by its handle; the rest is practically automatic. Holding-down wheels are provided to prevent the carriage from lifting or rising from the rails.—*Scientific American.*

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## ATMOSPHERIC ELECTRICITY.

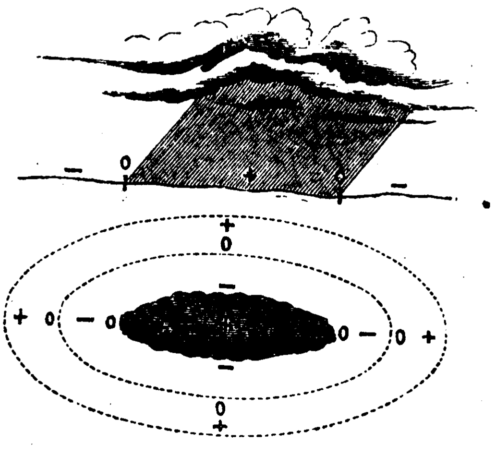

Fig. 1.

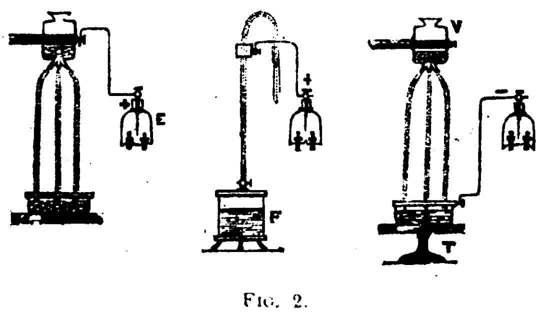

Fig. 2.

As far back as 1850 the author (M. L. Palmieri, in *La Lumière Electrique*) demonstrated that on exposing to the open air an insulated metallic vessel filled with water which can escape by one or several pipes into another metal vessel also insulated and placed at a level 2 or 3 metres below the former, we see the first vessel give decided indications of positive electricity whilst the water is escaping. This electricity, the presence of which is observed at the beginning of the stream, disappears further and then reappears, but in a negative state, augmenting in intensity as we approach the ground. If it is collected in the lower vessel it is found negative. If the upper vessel is not insulated we have merely negative electricity in the descending stream.

If the electricity of the air is negative the phenomena will be inverse; the upper vessel will indicate negative electricity and the lower positive. Fig. 1 shows the arrangements for these experiments.

If instead of using a liquid we take granules of lead, metallic powder or even volcanic ashes, the phenomena are identical.

Vesuvius has often given occasion to observe that the falling ashes are charged with negative electricity, but if the ascending smoke is very dense it renders it difficult to distinguish the negative electricity of the ashes. Hence sometimes the ashes falling upon the collecting disc appear negative if the instrument is kept motionless, but if the condenser is rapidly raised positive electricity is observed induced by the smoke which exists above.

The sands of deserts and even the dust of roads when falling show negative electricity. These facts come under the general law, that when a conductor is raised it shows in ordinary weather positive electricity, but when it is lowered negative electricity.

If negative electricity predominates in the air the law is inverted. From the experiments described above we are forced to conclude that water, by the mere fact of its falling, assumes negative electricity.

After this fundamental observation it was natural to suspect that rain, hail and snow ought in general to acquire negative electricity or, in general, electricity opposite to that of the air above. But on observation it was found that where rain is falling we have nearly always a strong positive electricity derived from the influence of the cloud which, as it resolves itself into rain, becomes an abundant source of positive electricity, so that the negative electricity of the rain may remain masked.

When falls of snow occur at the Observatory on Vesuvius the author has frequently observed negative electricity, especially when innumerable flakes driven by the wind and floating in the air fell outside the region in which they had been formed.

Sometimes, beneath rain there is negative electricity, but this is derived from another shower falling at a distance such that the place of observation is included in the zone of negative electricity which always surrounds a region of rain according to the law which the author discovered in 1854.

The difficulty of rendering manifest the negative electricity which rain must acquire in its fall springs precisely from the abundance of positive electricity developed by the clouds which are being resolved into water. If the upper vessel (fig. 1) which was in a neutral state becomes positively electrised when the liquid descends, it is plain that if it had been charged with positive electricity this would have increased during the fall of the water.

Hence it is that rain, hail and snow. which must by the mere fact of their descent assume negative electricity, increase the positive electricity of the cloud above and give rise to thunder, which is never produced without abundant rainfall.

The lightnings which in severe volcanic eruptions flash through the smoke rising from the crater seem to form an exception to this rule, but an abundant shower of ashes is a necessary condition for such lightning. Thus we may have great eruptions without lightning, and inversely. This is proved not merely by personal observations but by the figures and records of all the eruptions of Vesuvius. The small volcanic island which entered in eruption in August, emitting dense smoke with abundance of sand, has repeatedly presented the spectacle of lightning. But why is it so easy to see the negative electricity which a thin liquid stream acquires when falling a height of two or three metres from a metal vessel which, if insulated, acquires positive electricity, and so difficult to observe the negative electricity which atmospheric water must acquire when falling from the clouds above? The author suspects that this is due to the abundant positive electricity developed by the condensation of vapour. To have an experimental proof he electrified positively the upper insulated vessel whilst the descending stream gave negative electricity to the latter vessel. At once he saw this negative electricity diminish and then disappear in consequence of the charge given to the upper vessel.

The very powerful electricity collected in the rain, even when not storm rain, is in itself proof positive that a cloud when resolving itself into water becomes a plentiful source of positive electricity.

Certain grave errors on this question have occurred in an elementary treatise on electricity and magnetism lately published in France. Speaking of the origin of atmospheric electricity, the author says: "A seductive hypothesis sees in the evaporation of water the source of electricity. The vapour carries off the positive electricity, whilst the water and the earth retain the negative electricity. Unfortunately, no experiment undertaken to demonstrate this view has given decisive results." He further adds: "the fact that rain is generally negative seems in direct contradiction to the hypothesis."

If by negative rain the author means that in which the apparatus employed gives manifestations of negative electricity, he errs greatly, considering that under rain (fig. 2) we have generally a very strong positive electricity, and we now know how we may exceptionally have negative electricity under rain without derogating from the law of the development of electricity by the condensation of vapour, especially when it is converted into rain or snow.

If, on the other hand, by the negative electricity of rain we are to understand that which rain acquires by the fact of its descent, this being negative is the most striking proof of the predominance of positive electricity.

He says elsewhere, still recognising that the potential of the air is ordinarily positive: "In cloudy weather, especially in rain, and on rare exceptions under a clear sky, the potential of the air is negative and that of the ground positive."

The author, on the contrary, mentions that the potential of the air, whether the sky is clear or cloudy, is always positive unless rain, hail or snow is falling within a certain distance, or there are showers of sand ejected by a volcano or carried up by the wind.

And since then when rain is falling we have strong positive electricity with a narrow surrounding zone of intense negative electricity which begins with the rain, lasts and travels with it and disappears with it, it is certain that at a certain distance, which may be from 60 to 70 kilometres according to the author's observations, there is a cloud which is being resolved into rain or snow.

If this zone is very extensive, as it habitually occurs in heavy or stormy downfall, the observer may happen to be in this zone with the heavens perfectly serene over all his horizon, and if within this zone there are clouds resolving themselves into slighter rain below, the observer will find negative electricity persisting after the cessation of what we may call the secondary rains, and this because the negative electricity is not derived from the rain originating in the negative zone of the primary rain. This is the summary of the long period of experiments conducted on Vesuvius at 637 metres above the sea level.

These facts having been demonstrated by direct experiment with suitable apparatus, and under peculiarly favorable conditions, the author continues to maintain them in opposition to the assertions met with in certain works.

The phenomena of the liquid current descending, which the author studied in 1850, induced him to indicate a new method for the ordinary observations of electric meteorology ; but he does not find it perferable to the method of the movable conductor to which he adheres. Nevertheless, under peculiar conditions, he employs a water collector.

Sir W. Thomson, wishing to register the phenomena without the presence of an observer, made use of the above-mentioned collector and of an heterostatic electrometer which has been improved by M. Mascart. In consequence of the continued variations of atmospheric electricity from moment to moment, the use of a registering apparatus with continuous indications seems opportune.

At the Meteorological Congress of Rome the author proved that the curves obtained cannot have a truly scientific meaning unless we know the errors of dispersion, and M. Mascart admits that with the author's apparatus it is possible to verify the results furnished by the others. Without too much insisting on this point he wishes observers to be penetrated with the idea that in meteorology registering appliances are generally subsidiary to the instruments of direct observation.

In the study of atmospheric electricity direct observations are of capital importance, for if with each electric variation which we perceive we consider analytically the aspect of the heavens, we may determine the cause from which this variation proceeds. Whatever may be the sensitiveness and precision of a registering instrument, unless it is seconded by the observer, it will never indicate all that an experienced eye will detect and scrutinise.

Thus, for instance, we may observe negative electricity and have before us a vast horizon ; we see easily rain falling at a certain distance, and we find the negative electricity rapidly disappearing if the rain ceases. The apparatus will indicate only a part of this, and the incomplete observation will prove nothing. If we admit that the curves are free from error, they will give the history of the facts but not the key, the cause of the variations of atmospheric electricity.

The registering instruments, costly, complicated, and requiring assiduous care, cannot be readily admitted into every observatory, and it is not only by their means that we can discover the true laws of atmospheric electricity. We may rationally use them as auxiliaries where the conditions permit, but it is necessary that we calculate beforehand the value of the direct observations which may one day serve to interpret, and perhaps even to correct, the graphic curves.—*Electrical Review.*

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## JEWELL'S PATENT WATER PURIFIERS.

The subject of water purification is of such vital importance to every man, woman and child, that it claims the earnest attention, not only of the sanitarian, but of the entire public. All are anxiously awaiting the successful solution of this problem.

It is not within the scope of this article to relate the history of the efforts which have been made by scientists to produce pure water ; it is, however, deemed proper to present certain facts demonstrating what has been accomplished, and proving that a "Pure-Water System" has been devised, and that by its use the problem has been solved in a practical manner, upon a scale of any magnitude, and at a minimum cost of construction and maintenance.

The construction of the filter, which is illustrated on page 16, is such that the valve-system is connected to the side of the filter, which places the valve conveniently within easy reach of the attending engineer. These filters are so constructed that they can be connected to deliver the purified water on either the right or the left side, as may be required.

There are simply three connections to be made : One to introduce impure water, one to discharge the purified water, and the third to discharge the wash-water. In this system the main arms are made of extra strong pipe, while all of the lateral arms and their branches are heavy brass tubing with brass fittings leading to the patented brass and cone valves, by the use of which the attendant is enabled to reverse the currents of water in the filter, thoroughly cleansing the sand of all impurities in an exceedingly short period of time ; and the construction is such that during this operation there is no possibility that the filtering material can be washed out. These cone valves are automatic and positive in action, and it is a mechanical impossibility for them to become inoperative, as they open and close only by the water used in cleansing the filter. The outlet apparatus is fitted with an aluminum bronze screen, which cannot corrode, and the tensile strength of which is greater than that of steel. While the filter is being washed a separate current is forced in a reverse direction through this apparatus, thus insuring its perfect cleansing.

In purifying water, whether for potable, domestic or mechanical uses, it has been found to be absolutely necessary to use a coagulating substance to collect the impurities in order that they may be arrested and removed by the filter.

To accomplish this necessary feature a sight-feed pressure and vacuum chemical apparatus have been devised, which are shown in Figs. 2, and 3, herewith illustrated, the former, No. 2, being used when the filter is connected to a supply-pipe under pressure, such as a city main or reservoir, and the latter, No. 3, when the water is supplied by a pump.

Both of these devices are automatic and positive in action, allowing only a fixed quantity of chemical to pass into the water while the filter is in operation, and when the filter is shut off the flow of chemical ceases, thus preventing its waste. Opening the valves of the filter wlll cause either apparatus to work automatically. The "pressure tank" is attached by cutting out a short section of the vertical supply pipe and inserting the apparatus. The pressure of the water passing through the tank will cause the chemical to be forced into the supply pipe, where the desired chemical change in the impurities contained in the water will be occasioned. The "vacuum tank" is connected to the suction pipe, or into the suction head of the pump.

In operation, every stroke of the pump causes a fixed quantity of the coagulant to pass into the suction pipe, and thence through the pump, where it becomes intimately intermixed with the water, thereby producing a perfect aggregation or coagulation of the impurities contained in the water. Inside of the tank a ball-cock is placed which controls the flow of water and automatically supplies the necessary quantity to replace that which is drawn out by the pump, and prevents any overflow or waste of chemical. This tank is open at its top, and the quantity of chemical being used can be noted and replenished when required.

By either of these methods, the desired quantity of coagulant can be fed with absolute correctness, and, when necessary, two or more tanks can be attached to one filter ; and when properly regulated there will not be found a trace of the chemical used for the coagulant in the purified water delivered from the filters.

The chemicals used in this pure-water system form new combinations with the impurities contained in the water and

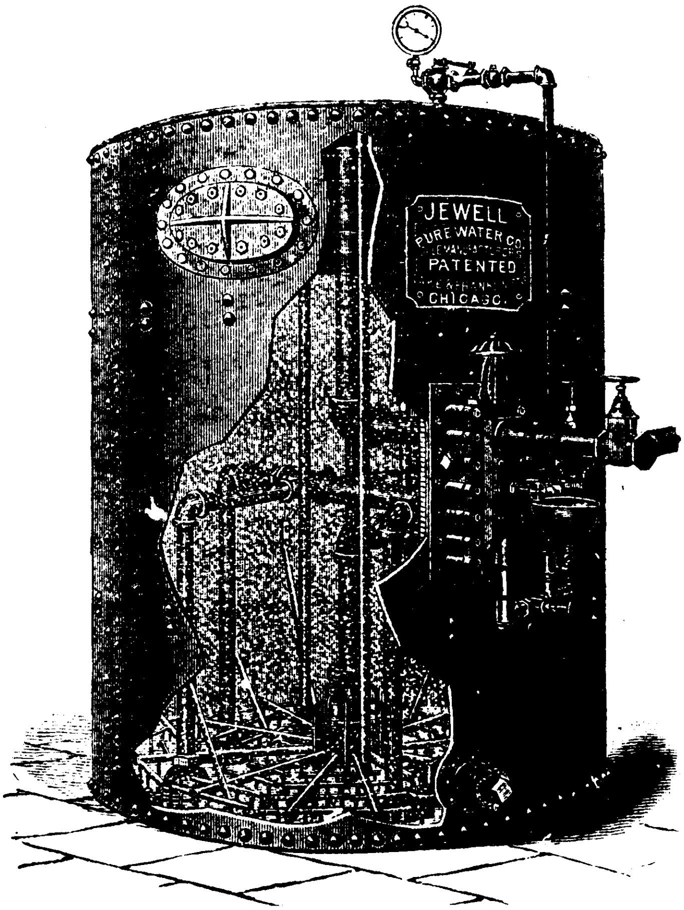


FIG. 1.—THE JEWELL WATER PURIFIER.

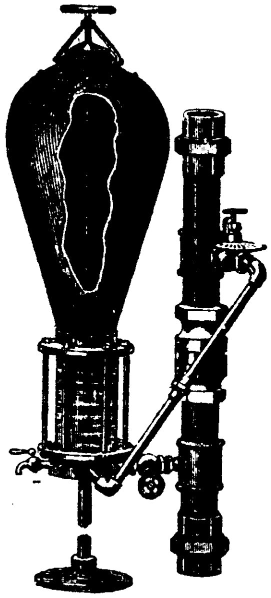


FIG. 2.—PRESSURE CHEMICAL TANK.

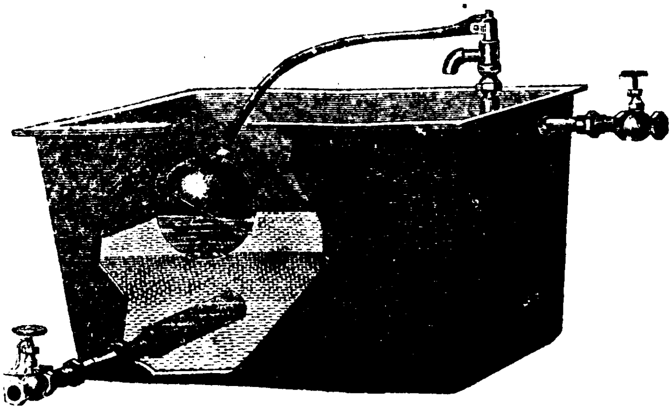


FIG. 3.—VACUUM CHEMICAL TANK.

are precipitated and retained in the filter-bed and passed off when the filter is washed.

Organic and other matter can sometimes be removed by the intimate intermingling of air with the water in the passage to the filter, the oxygen of the air tending to destroy the germs and organic impurities, which then pass to the filter and are retained in the sand. Water that has been thoroughly aerated, especially under pressure, and then filtered, is as free from dangerous matter and as near perfectly potable as can be obtained.

In connection with the manufacture of these purifiers, a fully equipped laboratory has been established where analysis of waters will be made, without charge, to determine the treatment requisite for its purification. In order to secure an accurate analysis, it is important that not less than two gallons of the water shall be forwarded, and that such sample shall be sent in glass and carefully corked and sealed. A copy of the analysis will be promptly furnished and the necessary treatment recommended, and, if proper, a guarantee be given.

The claims which are set forth for the "Jewell" pure-water system are: First, absolute perfection in purifying and softening waters; second, simplicity of system; third, quickness in cleaning; fourth, positive assurance that filter bed is perfectly clean after each washing; fifth, durability—no springs or complicated valves to be soon worn out; sixth, strength in construction of all parts; seventh, steady and regular feeding of the coagulating or precipitating chemical.

Many testimonials are at hand demonstrative of the peculiar merits of this pure-water system. Among them is one from the Calumet and Hecla Mining Co., which has been using two of the Jewell filters for filtering the mine water for use in boilers. They have very much improved a very filthy water, and enabled the company to use it for feed, a thing for which it was before entirely unfit.—*Mining and Scientific Press.*

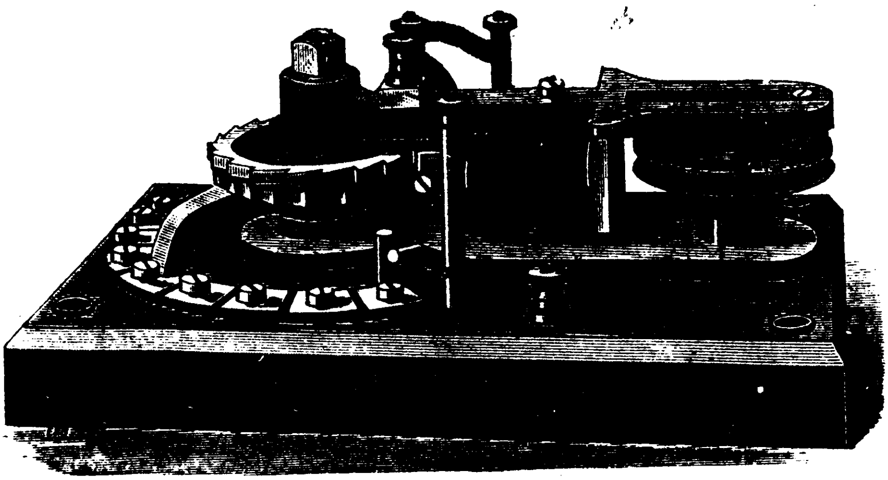


FIG. 2.

## SIR DAVID SALOMONS' RESISTANCE GOVERNOR.

This instrument has been designed by Sir David Salomons for use in connection with the well-known repulsion regulator, and is made by the Woodhouse and Rawson Electric Manufacturing Company under his patents. It is intended for automatically introducing or withdrawing resistance from a circuit in case of an alteration of E.M.F., and in its mechanical construction is similar to that of the Porte Manville governor. The ratchet wheels are driven from any convenient rotating shaft, and, on an alteration of the E.M.F., an electro-magnet draws one of the pawls into gearing with the ratchet wheel below it, causing the brush to move on to an adjacent contact, and so on till the proper E.M.F. has been reached by addition or subtraction of the necessary resistance. In case of the brush being carried right round to either extremity of the contact pieces circuit is broken by its pressure against the contact pins

Fig. 2 is another form of instrument designed for the same purpose. In this the ratchet wheels do not revolve from the shaft, but the brush is given a step-by-step movement on the action of the electro-magnets, combined with the motion of the anchor escapement, which is mechanically driven from a shaft. —*Electrical Review.*

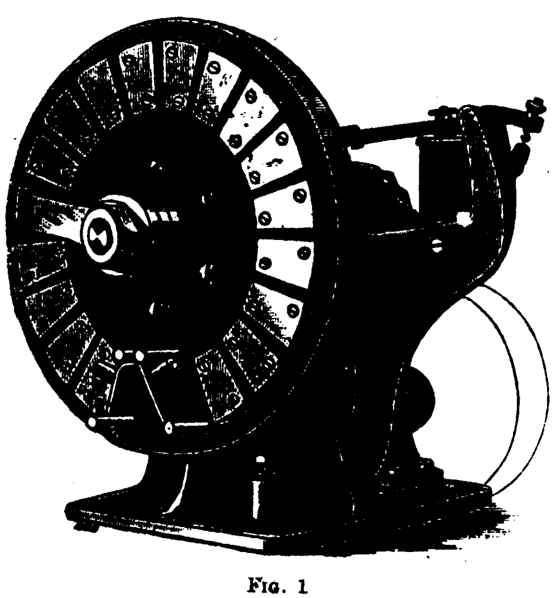


FIG. 1

## POISONS AND ANTIDOTES.

The following brief summary of the most rational and simple antidotes to the commoner form of poisons in daily use by artists and artisans, was compiled for the *American Analyst* by Dr. Francis Wyatt, and it will be seen that he has suggested the most appropriate to be applied in any emergency, pending the arrival, or in the total absence, of a skilled medical practitioner :—

| POISONS. | ANTIDOTES. |
|---|---|
| 1. Acid— Carbolic, sulphuric, muriatic, nitric, nitro-muriatic, creosote, iodine, phosphorus. | White of egg, well beaten up with water. A teaspoonful of mustard flour in a cup of hot water. Very thick lime water (in case of sulphuric, nitric, muriatic or nitro-muriatic acids). |
| 2. Chromic acid, chromates, all preparations or compounds of chromium, antimony, copper, mercury, or zinc. | Abundance of white of egg in water. A teaspoonful of mustard flour in water. Copious draughts of an infusion of salt herbs. |
| 3. Ammonia, soda, potash, alkalies, silicates, and sulphates. | Strong vinegar and water. Large doses of oil. Large doses of milk. |
| 4. Prussic acid and its salts, all cyanides and sulpho-cyanides, oil of bitter almonds, and nitro-benzine. | Continuous and heavy douches of ice-cold water over the head and spinal column. Mustard plasters on the stomach and soles of the feet. Prevent sleep. |
| 5. Ether, petroleum, benzine, fruits essence, concentrated or absolute alcohol. | Plenty of mustard flour in large quantity of hot water. Cold water douches. Fresh air. Prevent sleep absolutely. |
| 6. Compounds of baryta and lead. | A teasponful of mustard flour in warm water. Strong solutions of Epsom salts and Glauber's in cold water. |
| 7. Compounds of arsenic. | A teaspoonful of mustard flour in warm water. A teaspoonful of dialysed iron, mixed with the same quantity of calcined magnesia, every five minutes, for one hour ; then plenty of oil, or milk, or some mucilaginous tea—say linseed. |
| 8. Oxalic acid and its salts. | Very thick paste of lime and water by large spoonfuls at the time. After several of these, large draughts of lime water. Finally, four ounces of castor oil. |
| 9. Nitrate of silver. | Large doses of ordinary kitchen salt, dissolved in water, after which one teaspoonful of mustard flour in warm water. |
| 10. Nitrous fumes of vapours arising in vitriol or chemical works. | Frequent and small doses of strong acetic acid—the stronger the better. |

## DO STOVE-PIPE HATS MAKE BALD HEADS?

BY W. C. GOUINLOCK.

The habit of wearing warm coverings on the head is not of recent date ; the armies of Europe, for instance, no inconsiderable number of men, with heads close cropped, have worn for a long period warmer and heavier head-gear than the modern dwellers in cities, without the same tendency to baldness. Nor are the heavy fur coverings of northern races incompatible with luxuriant hair. It is also difficult to understand what injury can result from close cutting, *per se*. The growth is in the hair-follicle, and in it alone ; there is no vital connection between the hair outside the scalp and within ; it is usually cut closest at the back of the head and neck, where baldness never occurs. Would not close cutting rather stimulate the growth by exposure of the scalp ? Such at least is the popular belief. So, too, with indoor life ; women, who ought to show it most, whether in the home or in the factory, are never bald as men are ; on the contrary, it is most common with men in good circumstances, as Mr. Eaton's statistics show—men who spend a larger proportion of their daytime in the open air than the indoor worker.

I believe the common form of baldness is due entirely to the kind of hat that is worn, principally to the high hat and the hard felt hat, but also to any other head-covering *that constricts the blood-vessels which nourish the hair-bulbs.* To have a clearer understanding of this, we must remember that the scalp is supplied with blood by arteries at the back, sides, and front of, and lying close to the skull, which diminish in size by frequent branching, as they converge toward the top of the head. They are in a most favourable position to be compressed, lying on unyielding bone and covered by thin tissue. Consider what effect must be produced by a close-fitting, heavy, and rigid hat ; its pressure must lessen to a certain extent the flow of arterial blood, and obstruct to a greater extent the return of the venous ; the result being a sluggish circulation in the capillaries around the hair follicles and bulbs, a consequent impairment of nutrition, and final atrophy. This pressure is not trivial or imaginary, as any one will admit who has noticed the red band of congestion on the forehead when a hard hat is removed after moderate exercise. —*Exchange.*

NON-MAGNETIC WATCHES.—Watches are now made, so protected from magnetic influence as to be absolutely free from it, even when held in the immediate vicinity of the most powerful dynamo. Ever since the great railroads of the country have compelled their employes to provide themselves with timepieces that would not be affected by the magnetism generated by the car-trucks, there has been much speculation as to whether such a watch could be made, and a sharp rivalry has been going on between the American and Swiss manufacturers. The test was highly satisfactory, and once more proved that whenever a new invention was imperatively demanded American genius could fully hold its own against the whole world. Major King's magnet was so powerful that an ordinary watch was stopped stock still as soon as it came within three feet of it. Before the test was made there was quite a diversity of opinion among the experts present as to how far it would prove successful. Those who believed that a watch might be constructed that would resist magnetic influence under ordinary circumstances, were also of the opinion that when it was subjected to the most powerful magnet in the world, the steel pinions would jar so on the working parts that the watch must necessarily stop. For ten minutes the watch was held in front of the magnet, without any effect being discernible in its movements.—*Exchange.*

## AUTOMATIC HEAT REGULATION BY ELECTRIC MOTOR.

Our attention has lately been drawn to an ingenious system of automatic, electric, heat regulation, owned and operated by the Consolidated Temperature Controlling Company, of Minneapolis, Minn., and which appears to have merits of an unusual order. We are interested principally in the application of the method and apparatus employed to effect the control and regulation of steam heaters, hot-water heaters, and hot-air furnaces for domestic use, where the utility of the same is most obvious, and will most directly interest our readers.

There are many forms of damper regulators in use intended to control the rate of combustion of domestic heating apparatus. These are strictly mechanical devices, of which the operative mechanism is placed contiguous to the heating apparatus, or forms a part of it, and is rendered operative by the temperature of the hot-air chamber, or some corresponding member of the heating apparatus. This method of operation is too well-known to our mechanical readers to require explanation.

The system of heat regulation about to be described differs from the mechanical damper regulators here alluded to, both in the manner of applying the regulation and in the means employed.

The friends of the electric regulation system urge, and, we think, forcibly, that the principle of regulating the temperature of the living rooms of a house by means of devices actuated from the furnace or heater is radically wrong, since the temperature of the hot-air chamber of a furnace (taking this as an example) bears no relation to the temperature prevailing in those apartments which are situated some distance from the source of heat. The draught openings of a furnace controlled mechanically, may be closed before the temperature of these apartments has been brought to the point of comfort, or *vice versa*, by reason of irregular conditions prevailing in the apartments themselves, of which the mechanical regulator at the furnace or heater can have no cognizance, and to which it cannot therefore respond. This objection appears to us to be sound.

In contradistinction to this method, the electric system effects the regulation of the furnace heat from the living apartments, the sensitive apparatus placed therein in some convenient place actuating the regulating mechanism contiguous to the furnace according to the temperature prevailing in the rooms. No one will question that this method is distinctly the more scientific of the two ; and if it can be shown that the apparatus employed in its operation is simple, effective, automatic, and reliable, it should afford as complete a solution of the problem involved as could be desired.

We give in the following a brief description of the electric system here referred to, from which our readers may judge how completely the problem is solved by its application :—

The regulator consists of a thermostat, which is placed in the apartment, the temperature of which is to be regulated. This thermostat is connected by wires with an ordinary open-circuit battery, which may be placed in the furnace-room. The battery is connected with a spring motor of special form, which in turn is connected with the front and check dampers of the furnace in such a manner that, as the one is closed, the other wlll be opened, and *vice versa*.

The arrangement of the apparatus in connection with a hot-air furnace is shown in Fig. 1. The thermostat is seen secured upon the wall in one of the rooms of the house. The electric wires are connected with the thermostat, and run in the wall to the furnace room. The thermostat may be located in any room in the house, and at any distance from the furnace. The motor is located, preferably, either directly over the check damper, as in the picture, or over the front damper. A chain is run from the crank on the motor shaft to the front damper, and one to the check damper. One damper opens as the other closes, and the dampers thus balance each other. The battery is placed on a shelf at any convenient point. One wire runs from the thermostat to one pole of the battery, two wires run from the thermostat directly to the motor, and another wire runs from the battery to the motor. The thermostat may be set for any desired temperature.

The apparatus thus arranged is extremely sensitive, and the temperature of the room may be controlled within the limits of one degree of temperature above or below that for which the thermostat is set.

As soon as the temperature exceeds that for which the apparatus has been adjusted, one electric circuit is closed at the thermostat, which at once actuates the spring motor, the crank-shaft of which makes one-half revolution, and then stops. This motion opens the check damper and closes the front damper, and the fire is thus slightly checked. As soon as the air in the room has cooled off one degree, the thermostat closes the other circuit, and the motor is again set in action, but in the reverse direction, by which also the position of the dampers will be reversed. As the electric circuits are each broken by the motor in the act of starting, but little battery power is consumed. By simple adjustment of the thermostat the heat of the apartment may be reduced ten, twenty, or more degrees at night, as may be desired.

It will be perceived from this account of the operation of the system, that its action is entirely automatic, and its regulating power over the temperature of the apartment complete, the range of permissible variation depending upon the sensitiveness of the thermostat employed. As the apparatus exerts an effectual control over the rate of combustion in the heater, it must effect a decided saving in fuel. This saving, it is affirmed, will reach from 25 to 33 per cent. of that consumed in ordinary practice.

Fig. 2 exhibits the appearance of the motor employed. It is light, compactly built, and strong. It is provided with an index that shows when it needs re-winding, with an automatic circuit breaker which breaks the circuit should the motor accidentally be allowed to run entirely down, thereby preventing the polarizing of the battery, and with a stop that prevents winding up too far.

With this system and apparatus, the regulation of the temperature of the living rooms of the house may be effectually controlled with the minimum of care and attention, the only thing to be looked after being the coal supply of the heating apparatus and the removal of the ashes.

In addition to the regulation of the heating apparatus of dwellings, this system, with immaterial modifications in details, may be applied with equal effectiveness to other purposes, such as the regulation of the temperature in green-houses, railway cars, etc., and generally to any kind of heating apparatus.

It appears to possess a number of meritorious features which should commend it to the favourable attention of those who may be interested in the subject.—*The Manufacturer and Builder.*

◆

To make a cherry stain, mix together, by stirring, one quart of spirits of turpentine, one pint of japan, one pound of Venetian red, ground in oil, and two ounces of dry burnt umber. Apply with a brush and wipe off with a cloth. Finish with one coat of shellac and two coats of varnish.

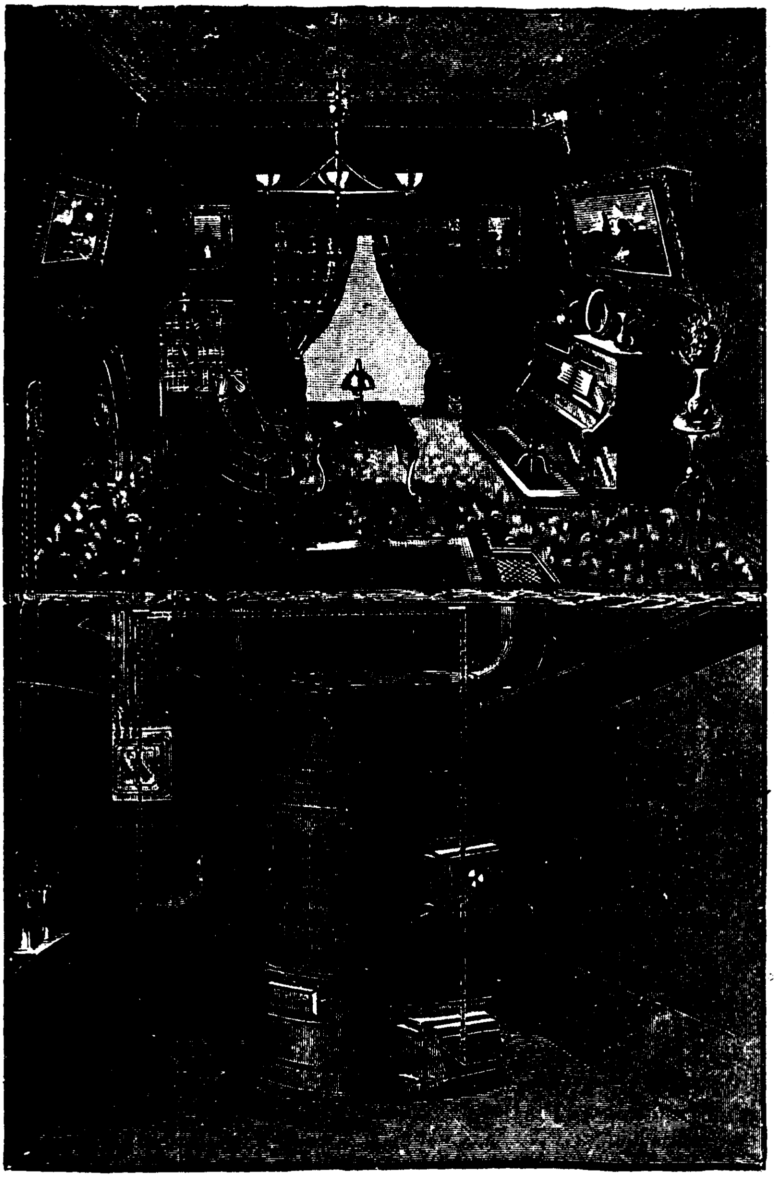


FIG. I.—THE ELECTRIC TEMPERATURE REGULATOR APPLIED TO A HOT-AIR FURNACE.

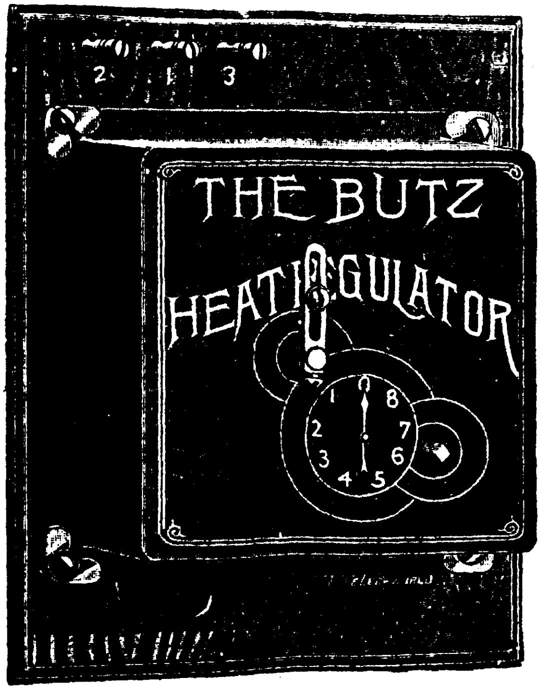
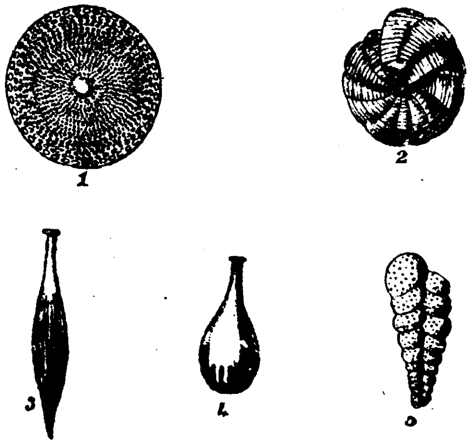
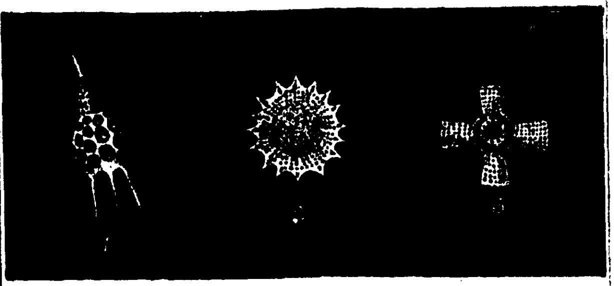


Fig. 2.—The Motor.



Group 1 Represents Foraminifera.



Group 2.—Polycistina.

## PROTOPLASM A BUILDER.

By Henry J. Slack, F.G.S., F.R.M.S.

Everyone who looks through a microscope at such objects as the shells of foraminifera or the artificial manufactured-looking spiculæ of many sponges, is struck by their curiosity, or their elegance ; but there the interest ends, unless it is enlarged and supported by some elementary scientific knowledge. The architectural and implement-forming abilities of minute jelly specks, operating without tools, and without any structure analogous to the organs of higher creatures, is not only wonderful, but beyond the powers of science to explain, though we may acquire some notion of how the work is performed.

If we looked at an *amœba* under a magnification of a few hundred times linear, we see a small bit of jelly chemically allied to white of egg, and in it are embedded numerous particles varying in translucence and in refractive power ; but no enlargement, and no persistence in observation, enables us to assign particular functions to any of these particles. though we know they are employed in different kinds of work. We cannot impute conscious purpose to any of the lower forms of life, but when an *amœba* goes slobbering about in search of food, its proceedings are far from mere random exertions of mechanical power. It is not obliged to make a mouth opening at any point unless, so to speak, it wants to close over an object that suits it. Some action of its surroundings upon it stimulate it to move about, and when its surface touches some small object it can assimilate it receives an impulse to take it in. Some of its molecules act like nerves, receiving impressions from without, and then determining other molecules to make the movements by which its living is obtained. We see some of the *amœbæ* protruding long delicate threads of protoplasm, while others only put forth thicker and blunt ones. These operate as feelers fumbling for prey, to which they are able to adhere and to engulf them ; they can also anchor the part that is most advanced, and drag the main body after it. This means that they have the power of regulating their stickiness, holding fast or letting loose as their mode of progression requires.

When they swallow an object we can see that they surround it with a clear space containing a fluid which acts chemically and digests it. Here, again, is a reception of and a response to a stimulus from a foreign body. Somehow, the molecules able to be impressed in this way must arrange themselves in a particular alignment to transmit force in a definite direction. For the moment, the pattern they form does work like that of an organ in higher animals. At any part of their body there are molecules ready to fall into rank and perform special work.

In their simplest conditions *amœbæ* have no formation of any structure to busy themselves with, but some of them put forth a bundle of *villi* or slender bristles.

Passing from naked *amœbæ* to the house-building foraminifera, we find structures that look like the work of cleverly-used tools, or special organs, performed by bits of protoplasm that have nothing of the kind. First, let us consider that the living jelly speck has to obtain the material for its building under what might seem great difficulties. It wants carbonate of lime, and the sea water it lives in contains only an infinitesimal quantity of that substance. In a thousand parts of the water of the Mediterranean there is 0·114 of one part of carbonate of lime, and less in the British Channel. By a chemical process it has to obtain this lime particle by particle, and it has to deposit each particle with exactness, as a good mason does with his bricks in erecting a house.

There are immense numbers of foraminifera differing from each other—so called species—each building according to its own pattern, and if extreme varieties or species are examined they might be supposed to belong to different families, but when the known species are studied in a series all the forms are seen to be related to each other and allied by connecting links. Obtaining the carbonate of lime and building it up in so many curious patterns is done by small bits of protoplasm in which no one can detect any structure capable of indicating what pattern they are able to form, or how they can transmit the ability to their descendants through countless generations. If we look at the shells of the polycistina we see singularly beautiful specimens of what looks like ornamental glasswork, the material being silex, with which we are familiar in the form of flint. But sea water contains so little silica that it is usually left unmentioned in the published analyses.

Chemical processes were formerly supposed to be controlled in living bodies by an imaginary vital force, but this delusion has been dispelled, and it is found that they act in organisms as they do in laboratories, the part of the organism being to provide suitable apparatus to bring the right things together and facilitate their work. Each acting membrane of a gland, for example, being adapted to give a preferential entrance or exit to particular fluids holding certain matters in solution, just as a bit of parchment paper lets solution of crystalline bodies pass through it, while the gummy or colloid sort of matter is retained.

The protoplasm of sponges varies in constructive powers according to the species. Some kinds, like toilet sponges, form a horny skeleton, others make one of carbonate of lime, and others of silex. In these great variety of pattern may be discovered, many of great beauty. Many sponges make themselves very unpleasant for their enemies to eat by filling their soft parts with implements like pikes, darts, barbed spears, exquisitely made fish hooks, caltrops, &c., &c.

Different species use different weapons, just as different races of pugnacious men do. The effect is, that if an enemy takes a bite, the result is as uncomfortable as eating a pudding full of pins.

The protoplasm is chemically the same kind of substance wherever it is found, and no microscopic examination of it informs us what kind of constructive work it can perform. There must, however, for each special kind of work be a transmission of motion or force in special directions. The arrangement of mineral substances in the patterns required is not effected by simple precipitation of the lime or silex from its solution. The living substance grows into the shape required, and the mineral stuff is infiltrated into it.

The hyaline glassy foraminifera build their shells with numerous minute holes to let fine threads of protoplasm pass through and select their food, beside performing respiratory functions. In polycistina are similar apertures, usually larger than in most of the foraminifera.

The figures, copied from the *Micrographic Dictionary*, will illustrate the preceding remarks.—*Knowledge.*

## PATENTS FOR SMALL THINGS.

Among these may be mentioned the "stylographic pen," and a pen for shading in different colors, producing £40,000 per annum. The rubber tip at the end of lead pencils has yielded £20,000. A large fortune has been reaped by a miner who invented a metal rivet or eyelet at each end of the mouth of coat and trousers pockets, to resist the strain caused by the carriage of pieces of ore and heavy tools. In a recent legal action it transpired in evidence that the inventor of the metal plates used to protect soles and heels of boots from wear sold 12,000,000 plates in 1879, and in 1887 the number reached 143,000,000, producing realized profits of a quarter of a million of money. As large a sum as was ever obtained for any invention was enjoyed by the inventor of the inverted glass bell to hang over gas to protect ceilings from being blackened, and a scarcely less lucrative patent was that for simply putting emery powder on cloth. Frequently time and circumstances are wanted before an invention is appreciated, but it will be seen that patience is well rewarded, for the inventor of the roller skate made over £200,000, notwithstanding the fact that his patent had nearly expired before its value was ascertained. The gimlet-pointed screw has produced more wealth than most silver mines, and the American who first thought of putting copper tips to children's shoes is as well off as if his father had left him £400,000 in United States bonds. Upward of £2,000 a year was made by the inventor of the common needle threader. To the foregoing might be added thousands of trifling but useful articles from which handsome incomes are derived or for which large sums have been paid. Few inventions pay better than popular patented toys. A clergyman realized £400 a week by the invention of a strange little plaything to be seen for a long time in every toy shop window, and even in the streets of London. That favorite American toy, the "return ball"—a wooden ball with an elastic attached—yielded the patentee an income equal to £10,000 a year, and an income of no less than £15,000 per annum to the inventor of the "dancing Jim Crow." The invention of "Pharoah's serpents," a toy much in vogue some years ago, was the outcome of some chemical experiments, and brought the inventor more than £10,000. The sale of the little wooden figure "John Gilpin" was incredibly large for many years, and a very ingenious toy, known as the "wheel of life," is said to have produced upward of £100,000 profit to its inventor. One of the most successful of modern toys has been the "chameleon top," the sale of which has been enormous. The field of invention is not only vast and varied, but it is open to everybody without respect to sex or age, station or means.—*Invention, London.*

## MURDER CULTURE BY THE PICTORIAL ARTS.

No fact is more patent to science than the direct effect of influences exerted through the medium of the senses upon the brain—that particular part of the organism whose functioning we call "mind." Darwin, Ruskin, and all the great students of development have labored to bring this fact within the cognizance of the general thinking public. That they have failed is only too painfully evidenced by the persistence and surprising ingenuity of the practice of cultivating homicidal propensities, and collaterally murder, by a refined use of the art of mural decoration.

While we empower the police to put down with a strong hand the exhibition in shop windows, and the censor of stage plays and spectacles to interdict the parade in theatres, of pictures and scenes of an "immoral" character, because it is recognized that these have a tendency to corrupt the mind of youth—and age too—nothing whatever is done to restrain the daily increasing evil of pictorial placards displayed on every boarding, and of highly wrought scenes produced at nearly all the theatres, which not only direct the thoughts, but actively stir the passions, of the people in such way as to familiarize the average mind with murder in all its forms, and to break down that protective sense of "horror" which nature has given us, with the express purpose, doubtless, of opposing an obstacle to the evil influence of the exemplification of homicide. It cannot be disguised that even the most sensitive nature is to some extent brutalized by the display of these pictures.

We are none of us as shocked at the spectacle of a knife driven into the chest of a young woman, and do not recoil as violently from the idea of this form of murder, as before the display on all sides of an elaborate, nearly life size, picture of the deed. Nor do two men grappling together and stabbing each other, or one man shooting another with a revolver, strike us as presenting spectacles of such hideous enormity as they would have done had we not been familiarized with these scenes by impressive placards staring us in the face at every turn. It does seem strange—passing strange—that this murder culture by the educationary use of the pictorial art has not been checked by public authority.

We have no wish to make wild affirmations, but knowing what we do, as observers of development, we can have no hesitation in saying that the increasing frequency of horribly brutal outrages is by no means unaccountable. The viciously inclined are, in a sense, always weak-minded—that is to say, they are especially susceptible of influences moving them in the direction their passions incline them to take; and when the mind (or brain) is impressed through the senses, and particularly the sense of sight, in such manner as to produce mental pictures, either in waking thought or dreams, of homicide, the impulsive organism is, as it were, prepared for the performance of the deeds which form the subjects of the consciousness. We are, of course, writing technically, but the facts are indisputable, and we trust they will be sufficiently plain. It is high time that this ingenious and persistent murder culture should cease.—*Lancet.*

## A NOVEL SCHEME FOR HARBOUR DEFENCE.

According to a recent report in some of the Philadelphia newspapers, a large company, backed by millions of dollars, has proposed to the Secretary of the Navy a striking and possibly effective scheme for the defence of that harbour and the harbours of other cities, from the attacks of an enemy's fleet, by shooting ignited petroleum at the unfriendly ships from the bottom of the river and burning them up. The Rear-Admiral has been directed to study closely the harbour of Philadelphia and its approaches. The petroleum defence scheme, the originators of which have induced the Government to make this preliminary examination of the Philadelphia harbour, is a brilliant one in more respects than one. A company has been organized at Washington to develop the plan and to show its practicability.

It is proposed to sink perforated iron pipes in the river bed and the approaches to the harbour, through which petroleum can be forced to the surface of the river by machinery and at a high pressure. In this way a fierce stream of blazing oil can be sent down on the enemy's fleet, to destroy it or drive it away. It is claimed by the projectors that a flame can be produced in this way as high as a ship's mast, and sent with terrific force on the attacking vessels many miles from the point where the oil is supplied to the system of submerged pipes. Iron vessels could not pass through this lake of fire, because it could be made to extend many miles along the river. An experiment in connection with the scheme will be made at Fort Mifflin in a few weeks. The necessary apparatus is almost ready at the present moment, and great things are expected from this test.

## DANGERS IN GASOLINE

The extensive introduction of gasoline stoves within the last few years has brought into very general domestic use an article, the presence of which in a dwelling-house is a constant menace to life and property. Gasoline, since its discovery, has always been known to chemists to be a dangerous substance. It evaporates rapidly at ordinary temperature, and its vapour, when mixed with ordinary air, in proper proportion, forms an explosive compound the same as does ordinary illuminating gas. It is stated that one pint of gasoline, when evaporated, will render explosive 200 cubic feet of air. The vapor of gasoline is in some respects more dangerous than common illuminating gas, especially the variety of gasoline which is ordinarily used in connection with gasoline stoves.

Dr. John H. Kellogg, of the Michigan State Board of Health, who was appointed to investigate the dangers in gasoline, has made a report, embodying facts which he has collected, and including the views of leading insurance agents, &c., concerning the dangers in the use and storing of gasoline, declared to be "more dangerous than gunpowder." He offers the following rules for the use and care of gasoline, and they embody facts and cautions which should be constantly kept in mind by every person employing or keeping this dangerous article.

1. Gasoline is an extremely dangerous, explosive substance.

2. It should be kept in a cool, well ventilated place, if possible out of doors, or in an out-building; never in a kitchen, closet, or cellar.

3. A vessel containing gasoline, unless tightly closed, should never be brought within 10ft. of a lamp, stove, grate, flame, or fire of any sort. The small flame of a match, or even a spark is sufficient to explode the gas when present in sufficient quantity.

4. The vapour of gasoline may be carried by a draught or current of air, and thus be brought in contact with fire at a considerable distance, even greater than that mentioned in the preceding paragraph; consequently gasoline should never be opened or poured from one vessel to another in a current of air, unless the current is from the room out of doors.

5. The danger in connection with the use of gasoline stoves is not so much in the stoves themselves as in having the gasoline about; yet by continued use the valves of a stove may become worn so that leaks may occur, and thus a stove may become a source of great danger.

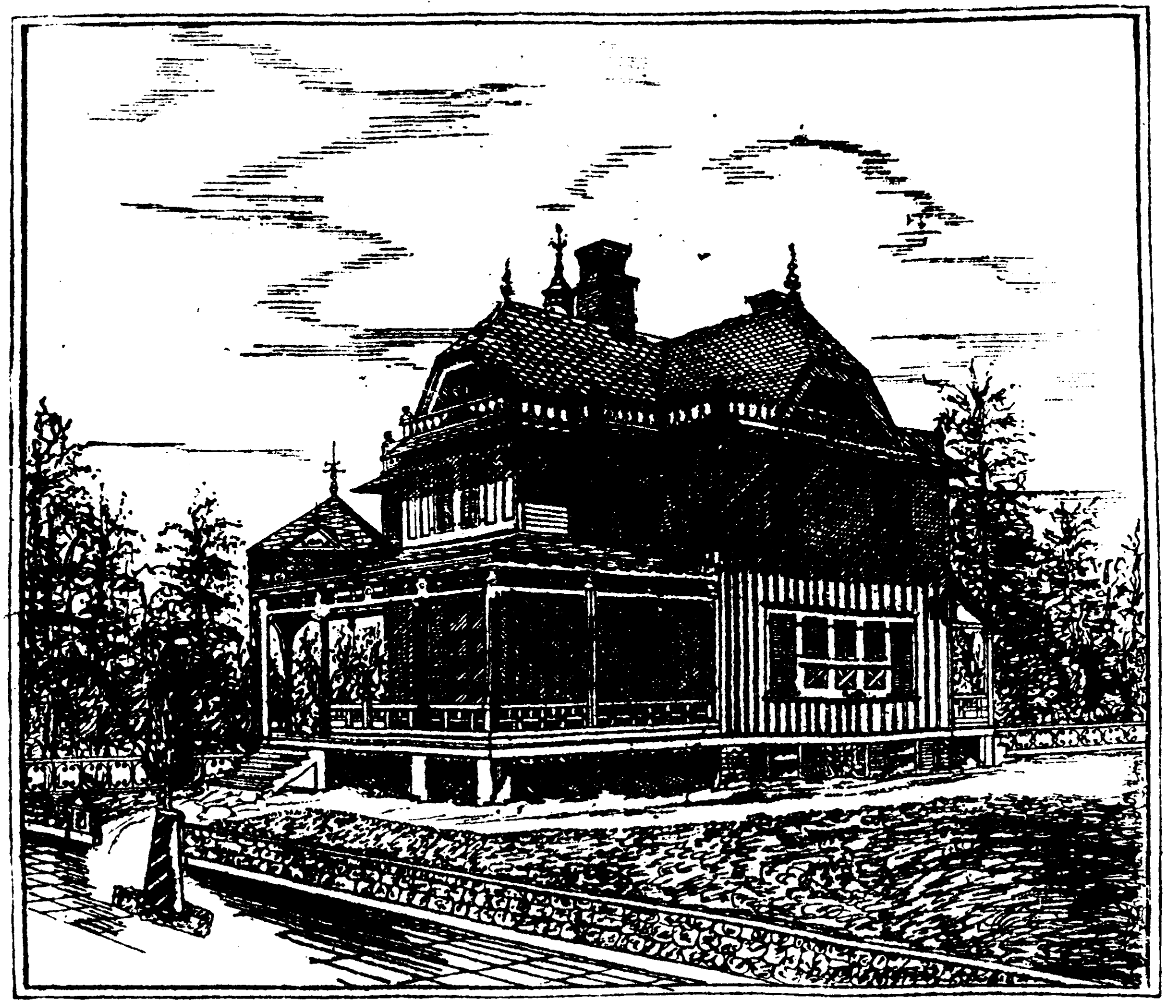
6. If an overflow of gas occurs from being turned on too freely, from leakage of valves, or from the blowing out of the generating burner, as sometimes accidentally occurs, the surplus gasoline should be carefully wiped up, and the room should be well aired by the opening up of windows and doors before the burner is lighted.

7. If an open vessel containing gasoline has been standing in a room over night, or an overflow has occurred during the night, or if there is found in a room a strong smell of gasoline at any time, the room should be opened and well-aired, or before a match is lighted, or a lighted lamp or candle carried into the room.

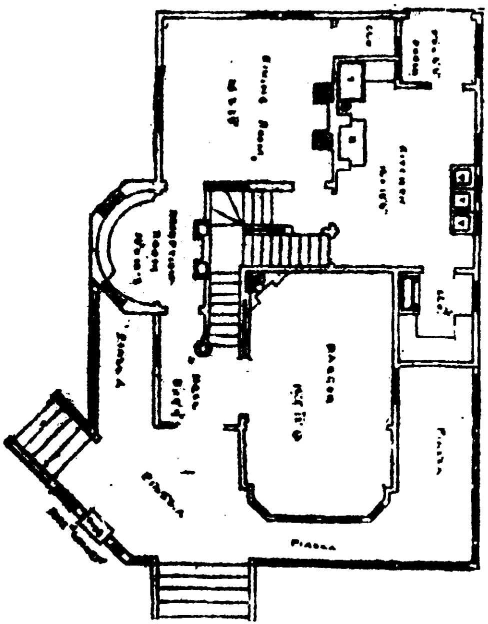
8. Gasoline should never be used for lighting a fire. An explosion, which may possibly be fatal in its effects, is almost certain to follow. Persons have been maimed for life in this way.

9. The use of gasoline lamps is, if possible, attended with even greater dangers than the use of gasoline stoves.

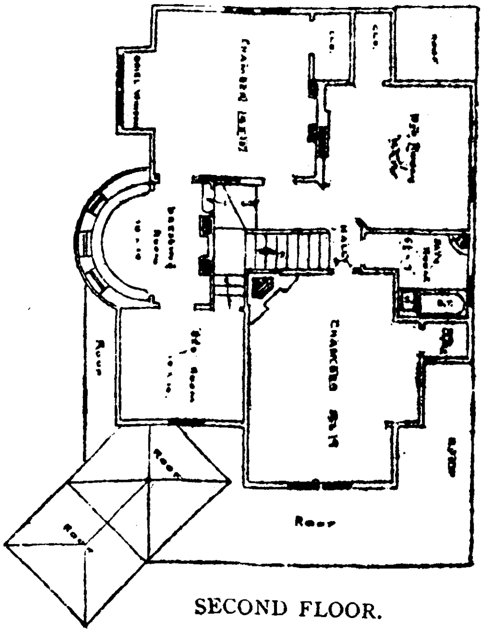
10. A wise regard for safety will lead to the disuse of gasoline in any form for domestic purposes.—*American Inventor.*



**DESIGN FOR COTTAGE, COSTING $4,000.**



FIRST FLOOR.



SECOND FLOOR.

## DESIGN FOR COTTAGE, COSTING $4,000.

The architectural illustration shown on the opposite page, is of a cottage designed by D. T. Atwood, architect, of 335 Broadway, New York, and erected at Bayshore, near Fort Hamilton, L.I., overlooking the Narrows.

The house is of wood, the frame being filled in with brick. The exterior details are of unique construction.

The interior contains all the modern improvements, including steam heat. The hall, reception-room, and parlour are finished in hard woods. The balance of the house is trimmed in oiled pine.

A good feature of the interior arrangement is the economizing of the hall space by a combination of the front and back stairs, using the platform of the latter to communicate with the rear staircase, communication being cut off with sliding doors.

An ample piazza extends around the front of the house, and there is a porch, 5 feet 6 inches by 6 feet 6 inches in the rear, off the kitchen.

On the first floor there is a parlour, 12 feet by 12 feet 6 inches; reception-room, 10 feet by 10 feet 3 inches; dining-room, 14 by 15 feet; kitchen, 12 feet by 15 feet 6 inches.

On the second floor there are four chambers of the following respective dimensions: 14 by 19 feet; 14 by 15 feet; 12 by 12 feet; and 10 by 10 feet. On this floor there is also a dressing-room, 10 by 10 feet.

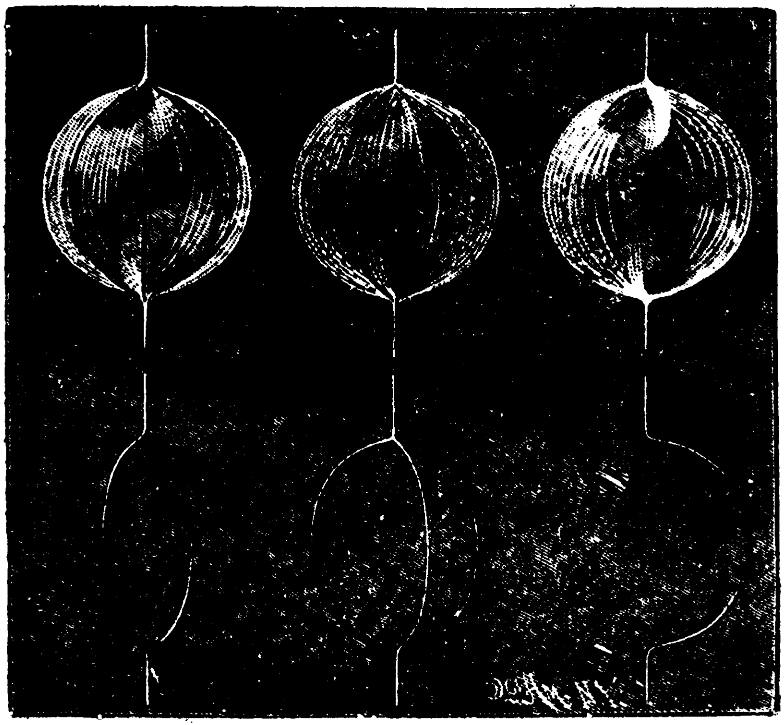
This house was erected for John Robinson, of New York, and cost, complete, about $4,000.—*Exchange.*

## CURIOUS OPTICAL ILLUSION.

The engraving illustrates an interesting illusion observed by Mr. J. Rapieff, the well-known electrician. The apparatus consists of semicircular and circular wire loops, provided with axles, by which they may be twirled between the thumbs and fingers. The lower row of figures shows some of the loops used in the experiment, while the upper figures represent the effects produced. The wire has a polished surface. When the single semicircular loop is twirled, the only effect is to produce a gauzy glimmer of spherical form, as shown in the upper right hand figure. When three of the loops are joined together, each extending from the other at an angle of 120°, the figure produced is similar to that already described, but with two perfectly distinct curved black lines extending from one axle to the other, as shown in the upper central figure. When four loops are joined at right angles to each other, three jet black lines are shown, as indicated in the upper left hand figure. A circular loop shows a single black line.

This curious effect is produced by holding the apparatus so that the light is reflected as much as possible from the inner surface of the wire. The result is due to the eclipsing of the bright surface by the shaded portion of the upper loop as it passes between the eye and the lower loop. The whole of the loop is not eclipsed at the same instant, but persistence of vision causes the entire eclipse to be seen at once.

Success in this experiment depends upon holding the loops in the right position relative to the light, as well as the provision of the proper background. The loops should be held over a dark ground, with the axles parallel with the plane of vision. - G.M.H., in *Scientific American.*



CURIOUS OPTICAL ILLUSION.

## THE FOUNDATION-STONES OF THE EARTH'S CRUST.*

Do we know anything about the earth in the beginning of its history—anything of those rock masses on which, as on foundation-stones, the great superstructure of the fossiliferous strata must rest? Palæontologists by their patient industry have deciphered many of the inscriptions, blurred and battered though they be, in which the story of life is engraved on the great stone book of Nature. Of its beginnings, indeed, we cannot yet speak. The first lines of the record are at present wanting—perhaps never will be recovered. But apart from this—before the grass, and herb, and tree, before the "moving creature in the water," before the "beast of the earth after his kind,"—there was a land and there was a sea. Do we know anything of that globe, as yet void of life? Will the rocks themselves give us any aid in interpreting the cryptogram which shrouds its history, or must we reply that there is neither voice nor language, and thus accept with blind submission, or spurn with no less blind incredulity, the conclusions of the physicist and the chemist?

The secret of the earth's hot youth has doubtless been well kept. So well that we have often been tempted to guess idly rather than to labor patiently. Nevertheless we are beginning, as I believe, to feel firm ground after long walking through a region of quicksands; we are laying hold of principles of interpretation, the relative value of which we cannot in all cases as yet fully apprehend—principles which occasionally even appear to be in conflict, but which will some day lead us to the truth.

I shall not attempt to give you an historical summary, but only to lay before you certain facts for which I can answer, and to indicate the inductions which these, as it seems to me, warrant. If I say little of the work of others, it is not from a desire of taking credit to myself, but because it is immaterial for my present purpose who first made a particular observation and how far his inductions therefrom were correct. The acknowledgment of good work would involve repudiation of bad, and for that, so far as persons are concerned, it seems hardly fair to use the present occasion. So, in the outset of this lecture I will once for all make a statement which I have sometimes thought of invariably using, like a prefatory invocation, "You are free to suppose that everything herein has been said by somebody, somewhere," but I will add that, as far as possible, every assertion has been personally verified.

The name Cambrian has been given to the oldest rocks in which fossils have been found. This group forms the first chapter in the first volume, called Palæozoic, of the history of living creatures. Any older rocks are provisionally termed Archæan. These—I speak at present of those indubitably underlying the Cambrian—exhibit marked differences one from another. Some are certainly the detritus of other, and often of older materials—slates and grits, volcanic dust and ashes, even lava-flows. Such rocks differ but little from the basement-beds of the Cambrian; probably they are not much older, comparatively speaking. But in some places we find, in a like position, rocks as to the origin of which it is more difficult to decide. Often in their general aspect they resemble sedimentary deposits, but they seldom retain any distinct indications of their original fragmental constituents. They have been metamorphosed, the old structures have been obliterated, new minerals have been developed, and these exhibit that peculiar orientation, that rudely parallel arrangement, which is called foliation. Except for this some masses are fairly homogeneous, while some exhibit a distinct mineral banding which is usually parallel with the other structure. These rocks are the gneisses and schists—the latter term, often vaguely used, I always restrict to rocks which exhibit a true foliation. In some schists the mineral constituents are comparatively minute, in others they are of considerable size. In the former case we may often venture to affirm that the rock is a metamorphosed sediment; in the latter its original condition is a matter of conjecture. Rocks of the former class often appear, to use no stronger word, to lie above, and so to be less ancient than those of the latter, and beneath that comes a coarser and more massive series, in which granitoid rocks are common. In these last foliation is often inconspicuous, and the rocks in consequence are not markedly fissile.

That these rocks are older than the Cambrian can often be demonstrated. Sometimes it can even be proved that their present distinctive character had been assumed before the overlying Cambrian rocks were deposited. Such rocks, then, we may confidently bring forward as types of the earth's foundation stones. As the inscriptions buried in the Euphrates Valley tell us the tongue of Accad in the days prior to the coming of the Semite, so these declare what then constituted the earth's crust. If in such rocks we find any peculiarities of mineral composition or structure, these may legitimately be regarded as distinctive. We have only to beware of mistaking for original those which are secondary and subsequently impressed.

In other parts of the world we find rocks of like characters with those above named, the age of which cannot be so precisely fixed, though we can prove them to be totally disconnected from and much older than the earliest overlying stratum. To assert that these rocks are contemporary with the others is obviously an hypothesis which rests on the assumption that community of structure has some relation to similarity of origin. I am well aware that attempts have been made to discredit this. But if we eliminate difficulties which are merely sophistical—those, I mean, created by the use of ambiguous or misleading terms—if we acknowledge those due to our limited means of investigation, such as that of distinguishing a rock crushed *in situ* from one composed of transported fragments—in other words, of separating in every case a superinduced from a primary structure, and if we allow for others due to the limitation of our instrumental and visual powers, I do not hesitate, as the result of long and, I hope, careful work, to assert that certain structures are very closely related to the past history of a rock, and that in very many instances our diagnosis of the cause from its effect is not less worthy of confidence than that of an expert in pathology or physiology. Resemblances of structures, different in origin, do, no doubt, sometimes occur—resemblances not seldom due to partial correspondence in the environments; but in regard to these it is our duty to labour patiently till we succeed in distinguishing them. The difficulty of the task does not justify us, either in abandoning it in despair, or in sitting down, after a few hasty observations, to fashion hypotheses which have no better foundation than our own incompetence or idleness.

As it is impossible in the time at my disposal to demonstrate the proposition, I must assume what I believe few, if any, competent worker will deny, that certain structures are distinctive of rocks which have solidified from a state of fusion under this or that environment; others are distinctive of sedimentary rocks; others again, whatever may be their significance, belong to rocks of the so-called metamorphic group. I shall restrict myself to indicating, by comparison with rock structures of which the history is known, what inferences may be drawn as

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*An evening discourse, delivered at the Bath meeting of the British Association, by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., &c.

to the history of the last-named rocks, which, as I have already stated, are in some cases examples of the earth's foundation-stones, while in others, if they are not these, they are at any rate excellent imitations.

Let us proceed tentatively. I will put the problem before you, and we will try to feel our way towards a solution. Our initial difficulty is to find examples of the oldest rocks in which the original structures are still unmodified. Commonly they are like palimpsests, where the primitive character can only be discerned, at best faintly, under the more recent inscription. Here, then, is one of the best which I possess—a Laurentian gneiss from Canada. Its structure is characteristic of the whole group; the crystals of mica or hornblende are well defined, and commonly have a more or less parallel arrangement; here and there are bands in which these minerals are more abundant than elsewhere. The quartz and the felspar are granular in form; the boundaries of these minerals are not rectilinear, but curved, wavy, or lobate; small grains of the one sometimes appear to be inclosed in larger grains of the other. Though the structure of this rock has a superficial resemblance to that of a granite of similar coarseness, it differs from it in this respect, as we can see from the next instance, a true granite, where the rectilinear outline of the felspar is conspicuous. Here, then is one of our problems. This difference of structure is too general to be without significance. What does it mean?

It is more difficult to obtain examples of schist of like geological age, wholly free from subsequent modification. Apparently the structure and composition of the rock have rendered it more liable to disturbance. But those exhibited, though by no means perfect examples, may serve to indicate the structure of an Archæan schist, consisting mainly of quartz and mica. We may take them as representative of a considerable series of rocks, which are often associated in such a manner as to suggest that, notwithstanding their present crystalline condition, they had a sedimentary origin. Can this inference be justified?

How shall we attack this problem? Clearly, the most hopeful way is by proceeding from the known to the unknown. Now, among the agents of change familiar to geologists, three are admittedly of great importance; these are water, heat and pressure. As probably almost all changes in nature, with which we have to deal, have occurred in the presence of water, but those due to it alone are generally superficial, I shall assume its presence, and not attempt to isolate its effects. But we must endeavor to ascertain the results of pressure and heat, when acting singly and in combination, in modifying rocks of a known character; admitting, however, that probably while the one agent has been dominant, the other has not been wholly inoperative.*

The first effect of pressure due to great earth movements is to flatten somewhat the larger fragments in rocks, and to produce in those of finer grain the structure called cleavage. This, however, is a modification mainly mechanical. It consists in a re-arrangement of the constituent particles, mineral changes, so far as they occur, being quite subordinate. But in certain extreme instances the latter are also conspicuous. From the fine mud, generally the result of the disintegration of felspar, a mica, usually colourless, has been produced, which occurs in tiny flakes, often less than one-hundredth of an inch long. In this process, a certain amount of silica has been liberated, which sometimes augments pre-existing granules of quartz, sometimes consolidates independently as microcrystalline quartz. Carbonaceous and ferruginous constituents are respectively converted into particles of graphite and of iron oxide. Here is an example of a Palæozoic rock, thus modified. It originally consisted of layers of black mud and gray silt. In the former, this filmy mica has been abundantly developed; it is present also, as we might expect, to some extent in the latter. Observe that the original banded structure, notwithstanding the pressure, has not been obliterated. Another point also demands notice. The black lines in the section indicate the direction of the cleavage of the rock, which is, roughly speaking, at right angles to the pressure which has most conspicuously affected the district, while the microfoliation, as we may call it, appears to be parallel to the original bedding, and is thus anterior to the dominant cleavage. The two may form parts of a connected series of movements, but, at any rate, they are so far separated that the pressure which produced the one, acted, roughly speaking, at right angles to that which gave rise to the other, and the folia were developed before they were bent and torn.

Let us now pass on to examine the effects of pressure when it acts upon a rock already crystalline. Here, obviously it is comparatively unimportant whether the original rock was a true granite or a granitoid gneiss; for at present we are only concerned with the effect of pressure on a fairly granular crystalline rock. But in the resultant structures there are, as it seems to me, differences which are dependent upon the mode in which pressure has acted. They are divisible into two groups; one indicating the result of simple direct crushing, the other of crushing accompanied by shearing. In the former case, the rock mass has been so situated that any appreciable lateral movement has been impossible; it has yielded like a block in a crushing machine. In the latter, a differential lateral movement of the particles has been possible, and it has prevailed when (as in the case of an overthrust fault) the whole mass has not only suffered compression, but also has travelled slowly forward. Obviously, the two cases cannot be sharply divided, for the crushing up of a non-homogeneous rock may render some local shearing possible. Still it is important to separate them in our minds, and we shall find that in many cases the structure, as a whole, like the cleavage of a slate, results from a direct crush; while in others the effects of shearing predominate. The latter accordingly exhibit phenomena resembling the effects of a tensile stress. Materials of a like character assume a more or less linear arrangement, the rock becomes slightly banded, and exhibits, as has been said, a kind of fluxion structure. This phrase, if we are careful to guard against misconception, is far from inappropriate. The mass gradually assumes a fragmental condition under the pressure, and its particles as they shear and slide under the thrust, behave to some extent like those of a non-uniform mass of rock in a plastic condition, as, for example, a slaggy glass. But we must be on our guard, lest we press the analogy too far. The interesting experiments which have been made on the flow of solids, and on rolled-out plastic substances, while valuable as illustrations, represent, as it seems to me, a condition of things which must be of rare occurrence in a rock mass, pulverized by mechanical forces only. If I am to reason from them, I must regard the rock not as a fragmental solid—if the phrase be permissible—but as an imperfect fluid; that is to say, I must consider them as illustrative of structures in rocks which have yet to assume—not have already assumed—a crystalline condition.

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*Heat will, of course, result from the crushing of rock. This some consider an important factor in metamorphism, but I have never been able to find good evidence in favour of it, and believe that as a rule the rocks yield too slowly to produce any great elevation of temperature.

Illustrations of the effects of direct crushing in a granitoid rock are common in the Alps. Those of a shearing crush are magnificently developed near the great overthrust faults in the north-west Highlands of Scotland.

In the former case, where a granitoid rock has been affected only to a moderate extent, and the resulting rock in a hand specimen would be called a gneiss without any very definite mineral banding, we find that under the microscope it exhibits a fragmental structure, the felspars are often somewhat rounded in outline, are frequently rather decomposed and speckled with minute flakes of white mica of secondary origin, and commonly seem to "tail off" into a sort of stream of microlithic mica, which has doubtless resulted from the destruction of felspar, the residual silica making its appearance as minutely crystalline quartz. The original quartz grains have been broken up, and are now represented by smaller grains, often in rudely lenticular aggregates, like little "inliers" of quartzite. The original flakes of black mica have been tattered and torn, and now appear as streaky clusters of flakelets, often less than one-sixth the original length. In extreme cases of crushing, the felspar has almost disappeared, the constituents are all reduced in size, and the rock at first sight would no longer be called a gneiss, but a fine grained mica-schist. It has become extremely fissile, and the flat faces of the fragments exhibit a peculiar sheen, as if it had received a varnish of microlithic mica. In short, from a granitoid rock a microcrystalline mica-schist has been produced, which, however, differs markedly from the rock to which that name is ordinarily applied.

Let us now turn to a rock of similar nature, in which the effect of shearing is more conspicuous. I have selected a specimen, in which, as in the first example above, some of the felspar still remains in recognizable fragments. These, however, are commonly destitute of the "tail" of mica-microliths, and bear, at first sight, some resemblance to the broken porphyritic felspars which occur in a rhyolite. The mica, whether primary, but fragmental, or secondary, tends to get associated in undulating layers; the quartz also has a more uniform aspect and a more linear arrangement. In the most extreme cases the felspar all but disappears (though I fancy that it has here a better chance of surviving), the quartz and the mica are more and more aggregated in definite but thin bands, and the former, when viewed with crossing nicols, exhibits streaks, which for a considerable distance, are almost uniform in tint, as if its molecules under a stress definite in direction had acquired a polarity, so that groups of these act upon light almost like a single crystal.

The effects of mechanical deformation, followed by mineral change, are also remarkably conspicuous in the case of pyroxenic rocks. Augite, it is well known, is by no means a stable mineral, and under certain circumstances is readily transformed into hornblende. This occurs in more than one way without mechanical action, but of these I do not now speak. Only of late years, however, has it been known that pressure can convert a dolerite into a hornblende-schist. Of this, through the kindness of Mr. Teall, who first proved the occurrence of this alteration in Great Britain, I can show you an example. The rock, as you see, has lost the structures of a dolerite, and has assumed those characteristic of many hornblende-schists. I say of many, because, though the rock is distinctly foliated, it does not exhibit a conspicuous mineral banding. My own observations confirm those of Mr. Teall, though I have never been so fortunate as to obtain, as he did, a complete demonstration of the passage from the one rock to the other.

It seems, then to be demonstrated that, by mechanical deformation, accompanied or followed by molecular re-arrangement, foliated rocks, such as certain gneisses and certain schists, can be produced from rocks originally crystalline. But obviously there are limits to the amount of change. The old proverb, "You cannot make a silk purse of a sow's ear," holds good in this case also. To get certain results, you must have begun with rocks of a certain character. So that it is often possible, as I believe, to infer not only the nature of the change, but also that of the original rock. Hitherto we have been dealing with rocks which were approximately uniform in character, though composed of diverse materials—that is, with rocks more or less granular in aspect. Suppose, now, the original rock to have already acquired a definite structure—suppose it had assumed, never mind how, a distinct mineral banding, the layers varying in thickness from a small fraction of an inch upwards. Would this structure survive the mechanical deformation? I can give an answer which will at any rate carry us a certain way. I can prove that subsequent pressure has frequently failed to obliterate an earlier banded structure. In such a district as the Alps we commonly find banded gneisses and banded schists, which have been exposed to great pressure. Exactly as in the former case the new divisional planes are indicated by a coating of films of mica, by which the fissility of the rock in this direction is increased. The mass has assumed a cleavage-foliation. I give it this name because it is due to the same cause as ordinary cleavage, but is accompanied by mineral change along the planes of division; while I term the older structure stratification-foliation, because so frequently, if it has not been determined by a stratification of the original constituents, it is at any rate a most extraordinary imitation of such an arrangement. In many cases the new structure is parallel with the old, but in others, as in the "strain-slip" cleavage of a phylite, the newer can be seen distinctly cutting across the elder mineral banding. As an example, take a rock mainly consisting of quartz and mica. Sometimes there has been a certain amount of crushing of the constituents, followed by a re-crystallization of the quartz and the formation of a pale-coloured mica. Sometimes when the direction of the disturbance has been at right angles to the stratification foliation, the latter is made wavy, and the mica-flakes are twisted round at right angles to their original position. Sometimes there has been a dragging or shearing of the mass, so that a considerable amount of mica has been re-crystallized along the new planes of division. To put it briefly, I assert, as the result of examining numbers of specimens, that though in certain cases the new structure is dominant, a practised eye seldom fails to detect traces of the older foliation, while in a large number of instances it is still as definite as the stripe in a slate.

We have got, then, thus far, that pressure acting upon rocks previously crystallized can produce a foliation; but when it has acted in Palæozoic or later times, the resulting structures can be identified, and these, as a rule, are distinguishable from those of the most ancient foliated rocks, while at present we have found no proof that pressure alone can produce any conspicuous mineral banding. I am aware that this statement will be disputed, but I venture to plead, as one excuse for my temerity, that probably few persons in Great Britain have seen more of crystalline rocks, both in the field and with the microscope, than myself. So while I do not deny the possibility of a well-banded rock being due to pressure alone, I unhesitatingly affirm that this at present is a mere hypothesis—an hypothesis, moreover, which is attended by serious difficulties. For, if we concede that, in the case of many rocks originally granular, dynamic metamorphism has produced a mineral banding, this is only on a very small scale; the layers are but a small fraction of an inch thick. No one could for a moment confuse a sheared granite from the Highlands with a Laurentian gneiss from Canada or with an uninjured Hebridean gneiss. For the former to attain to the condition of the latter, the mass must have been brought to a condition which admitted of great freedom of motion amongst the particles, almost as much, in short, as among those of a molten rock. Clearly, the dynamic metamorphism of Palæozoic or later ages appears to require some supplementary agency. Can we obtain any clue to it?

An explanation of broadly-banded structures was long since suggested, and has recently been urged with additional force, which avoids some of our difficulties. We know that the process of consolidation in a coarsely crystalline rock has often been a slow one; the constituent minerals separate gradually from the magma, of which sometimes so little may remain, that a rock with a true glassy base has been mistaken for one holocrystalline. The residual and still unsolidified magma would admit of a slow flowing of the mass, but there would be so little of it that the crystals already individualized, though altered in position by differential movements, would be affected by strains, and liable to fracture. Such a rock, when finally consolidated, would exhibit many phenomena in common with a rock modified by dynamic metamorphism, but would differ in the greater coarseness of its structure. This may prove to be the correct explanation of the curious foliated and banded gabbros in the Lizard district. That some crystalline rocks must have passed through this stage I am now in a position to affirm, from evidence not yet published.

Let us, however, see whether another line of investigation may throw some light on our difficulty. I have already mentioned the effect produced by the intrusion of large masses of igneous rocks upon other rocks. These may be either igneous rocks already solidified, or sedimentary rocks. The former may be passed over, as they will not materially help us. In regard to the latter, the results of contact metamorphism, as it is called, are, as we might expect, very various. Speaking only of the more extreme, we find that sandstones are converted into quartzites; limestones become coarsely crystalline, all traces of organism disappearing, and crystalline silicates being formed. In clayey rocks all signs of the original sediments disappear, crystalline silicates are formed, such as mica (especially brown), garnet, andalusite, and sometimes tourmaline; felspar, however, is very rare. Fair-sized grains of quartz appear, either by enlargement of original granules or by independent crystallization of the residual silica. It is further important to notice that, as we approach the surface of the intrusive mass—that is, as we enter upon the region where the highest temperature has been longest maintained—the secondary minerals attain a larger size and are more free from adventitious substances—that is, they have not been obliged as they formed to incorporate pre-existing constituents. The rock, indeed, has not been melted down, but it has attained a condition where a rather free molecular movement became possible, and a new mineral in crystallizing could, as it were, elbow out of the way the more refractory particles. I can, perhaps, best bring home to you the result of contact-metamorphism by showing you what its effects are on a rock similar to that which I exhibited in illustration of the effect of pressure-metamorphism on a distinctly stratified rock. These are, in brief, to consolidate the rock, and while causing some constituents to vanish, to increase greatly the size of all the others. It follows, then, that mineral segregation is promoted by the maintenance for some time of a high temperature, which is almost a truism. I may add to this that, though rocks modified by contact-metamorphism differ from the Archæan schists, we find in them the best imitations of stratification-foliation, and of other structures characteristic of the latter.

One other group of facts requires notice before we proceed to draw our inferences from the preceding. Very commonly, when a stratified mass rests upon considerably older rocks, the lower part of the former is full of fragments of the latter. Let us restrict ourselves to basement beds of the Cambrian and Ordovician—the first two chapters in the stone-book of life. What can we learn from the material of their pages? They tell us that granitoid rocks, crystalline schists of various kinds, as well as quartzites and phyllites, then abounded in the world. The Torridon sandstone of Scotland proves that much of the subjacent Hebridean had even then acquired its present characteristics. The Cambrian rocks of North and South Wales repeat the story, notably near Llyafoelog in Anglesey, where the adjacent gneissoid rocks from which the pebbles were derived, even if once true granites, had assumed their differences before the end of the Cambrian period. By the same time similar changes had affected the crystalline rocks of the Malverns and part of Shropshire. It would be easy to quote other instances, but these may suffice. I will only add that the frequent abundance of slightly-altered rocks in these conglomerates and grits appears significant. Such rocks seem to have been more widely distributed—less local—than they have been in later periods. Another curious piece of evidence points the same way. In North America, as is well known, there is an ancient group of rocks to which Sir W. Logan gave the name Huronian, because it was most typically developed in the vicinity of Lake Huron. Gradually great confusion arose as to what this term really designated. But now, thanks to our fellow-workers on the other side of the Atlantic, the fogs, gendered in the laboratory, are being dispelled by the light of microscopic research and the fresh air of the field. We now know that the Huronian group in no case consists of very highly-altered rocks, though some of its members are rather more changed than is usual with the British Cambrians, than which they are supposed to be slightly older. Conglomerates are not rare in the Huronian. Some of these consist of granitoid fragments in a quartzose matrix. We cannot doubt that the rock was once a pebbly sandstone. Still the matrix, when examined with the microscope, differs from any Palæozoic sandstone or quartzite that I have yet seen. Among grains of quartz and felspar are scattered numerous flakes of mica, brown or white. The form of these is so regular that I conclude they have been developed, or at least completed, *in situ.* Moreover, the quartz and the felspar no longer retain the distinctly fragmental character usual in a Palæozoic grit, but appear to have received secondary enlargement. A rock of fragmental origin to some extent has simulated or reverted to a truly crystalline structure. In regard to the larger fragments we can affirm that they were once granitoid rock, but in them also we note incipient changes such as the development of quartz and mica from felspar (without an indication of pressure), and there is reason to think that these changes were anterior to the formation of the pebbles.

To sum up the evidence. In the oldest gneissoid rocks we find structures different from those of granite, but bearing some resemblance to, though on a larger scale than, the structures of vein-granites or the surfaces of larger masses when intrusive in sedimentary deposits. We find that pressure alone does not produce structures like these in crystalline rocks, and that when it gives rise to mineral banding this is only on a comparatively minute scale. We find that pressures acting upon ordinary sediments in Palæozoic or later times do not produce more than colourable imitations of crystalline schists. We find that when they act upon the latter the result differs, and is generally distinguishable from stratification-foliation. We see that elevation of temperature obviously facilitates changes and promotes coarseness of structure. We see also that the rocks in a crystalline series which appear to occupy the highest position seem to be the least metamorphosed, and present the strongest resemblance to stratified rocks. Lastly, we see that mineral change appears to have taken place more readily in the later Archæan times than it ever did afterwards. It seems then, a legitimate induction that in Archæan times conditions favorable to mineral change and molecular movement—in short, to metamorphism—were general, which in later ages have become rare and local, so that, as a rule, these gneisses and schists represent the foundation-stones of the earth's crust.

On the other side what evidence can be offered? In the first place, any number of vague or rash assertions. So many of these have already come to an untimely end, and I have spent so much time and money in attending their executions, that I do not mean to trouble about any more till its advocates express themselves willing to let the question stand or fall on that issue. Next, the statement of some of the ablest men among the founders of our science, that foliation is more nearly connected with cleavage than with structures suggestive of stratification. In regard to this I have already admitted, in the case of the more coarsely crystalline rocks, what is practically identical with their claim, for they also assert that when the banding was produced, very free movement of the constituents was possible; and in regard to the rest I must ask whether they were speaking of cleavage-foliation or stratification-foliation, which had not then been distinguished, and I know in some instances what the answer will be. The third objection is of a general nature. To prevent the possibility of misstatement I will give it as a quotation:—"To a geologist (especially one belonging to the school of Lyell) it is equally difficult to conceive that there should be a broad distinction between the metamorphic rocks of Archæan and post-Archæan age respectively, as that the pre-Tertiary volcanic rocks should be altogether different in character from those of Tertiary and recent times." Of course in this statement much depends on the sense attached to the epithet "broad." As an abstract proposition I should admit, as a matter of course, that from similar causes similar consequences would always follow. But in the latter part of the quotation lurks a *petitio principii.* During the periods mentioned volcanic rocks appear, as we should expect, to have been ejected from beneath the earth's crust similar in composition and condition, and to have solidified with identical environment. Hence the results, allowing for secondary changes, should still be similar. But to assume that the environment of a rock in early Archæan times was identical with that of similar material at a much later period is to beg the whole question. My creed, also, is the uniformitarian; but this does not bind me to follow a formula into a position which is untenable. Other studies with which I have some familiarity have warned me that a blind orthodoxy is one of the best guides to heresy. "The weakness and the logical defect of uniformitarianism"—these are Prof. Huxley's words—"is a refusal, or at least a reluctance, to look beyond the 'present order of things' and the being content for all time to regard the fossiliferous rocks as the *Ultima Thule* of our science." Now, speaking for myself, I see no evidence since the time of these rocks, as at present known, of any very material difference in the condition of things on the earth's surface. The relations of sea and land, the climate of regions, have been altered; but because I decline to revel in extemporized catastrophes, and because I believe that in Nature order has prevailed and law has ruled, am I therefore to stop my inquiries where life is no longer found, and we seem approaching the firstfruits of the creative power? Because palæontology is, perforce, silent; because the geologist can only say, "I know no more," must I close my ear to those who would turn the light of other sciences upon the dark places of our own, and meet their reasoning with the exclamation, "This is not written in the book of uniformity?" To do this would be to imitate the silversmiths of old, and silence the teacher by the cry, "Great is Diana of the Ephesians."

What, then, does the physicist tell us was the initial condition of this globe? I will not go into the vexed question of geological time, though as a geologist I must say that we have reason to complain of Sir W. Thomson. Years ago he reduced our credit at the bank of time to a hundred millions of years. We grumbled, but submitted, and endeavored to diminish our drafts. Now he has suddenly put up the shutters, and declared a dividend of less than four shillings in the pound. I trust some aggrieved shareholder will prosecute the manager. However, as a *cause célèbre* is too long a business for the end of an evening, I will merely say that, while personally I see little hope of arriving at a chronological scale for the age of this earth, I do not believe in its eternity. What, then, does the physicist tell us must have been in the beginning? I pass by those earliest ages, when, as "Ilion, like a mist, rose into towers," so from the glowing cloud the great globe was formed. I pass on to a condition more readily apprehended by our faculties—the time, the *consistentior status* of Leibnitz, when the molten globe had crusted over, and its present history began. Rigid uniformitarian though you may be, you cannot deny that when the very surface of the ground was at a temperature of at least 1000° F., there was no rain, save of glowing ashes—no river save of molten fire. Now is ending a long history with which the uniformitarian must not reckon—of a time when many compounds now existing were not dissolved but dissociated, for combination under that environment was impossible. Yet there was still law and still order—nay, the present law and order may be said even then to have had a potential existence—nevertheless to the uniformitarian gnome, had such there been, every new combination of elements would have been a new shock to his faith, a new miracle in the earth's history. But at the times mentioned above, though oxygen and hydrogen could combine, water could not yet rest upon the ruddy crust of the globe. What does that mean? This, that assuming the water of the ocean equivalent to a spherical shell of the earth's radius and two miles thick, the very lava-stream would consolidate under a pressure of about 310 atmospheres, equivalent to nearly 4000 feet of average rock.*

But on the practical bearing of this consideration I will not dwell. Let us pass on to a time which, according to Sir W. Thomson, would rather quickly arrive, when the surface of the crust had cooled by radiation to its present temperature. Let us, merely for illustration, take a surface temperature of 50° F. (nearly that of London), and assume that the present rise of crust temperature is 1° F. for every 50 feet of descent, which is rather too rapid. If so, 212° F. is reached at 8100 feet, and 250° F. at 10,000 feet. Though the latter temperature is far from high, yet we should expect that under such a pressure chemical changes would occur with much more facility than

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*If we take the specific gravity of water as unity, and that of mean rock as 2·7, the pressure would be = 3911·1 feet of rock.

at the surface. But many Palæozoic or even later rock masses can now be examined which at a former period of their history have been buried beneath at least 10,000 feet of sediment ; yet the alteration of their constituents has been small ; only the more unstable minerals have been somewhat modified, the more refractory are unaffected. But for a limited period after the *consistentior status*, the increase of crust temperature in descending would be far more rapid ; when one-twenty-fifth of the whole period from that epoch to the present had elapsed, and this is no inconsiderable fraction, the rate of increase would be 1° for every 10 feet of descent. Suppose, for the sake of comparison, the surface temperature as before, the boiling-point of water would be reached at 1620 feet, and at 10,000 feet, instead of a temperature of 250° F., we should have one of 1050° F. But at the latter temperature many rock masses would not be perfectly solid.[*]

According to Sorby, the steam cavities in the Ponza trachyte must have formed, and thus the rock have been still plastic at so low a temperature as 680° F. At this period, then, the end of the fourth year of the geological century, whatever be its units, structural changes in igneous and chemical changes in sedimentary rocks must have occurred more readily than in any much later period in the world's history. A temperature of 2000° F., sufficient to melt silver—more than sufficient to melt many lavas—would have been reached at a depth of about 4 miles. It would now be necessary to descend for at least 20 miles in order to arrive at this zone. It, during the ninety-six years of the century, has been changing its position in the earth's crust, more slowly as time went on, from the one level to the other.

There is another consideration, too complicated for full discussion, too uncertain, perhaps, in its numerical results to be more than mentioned at present, which, however, seems to me important. It is this, that in very early times, as shown by Prof. Darwin and Mr. Davison, the zone in the earth's crust, at which lateral thrust ceases and tension begins, must have been situated much nearer to the surface than at present. If, now, at the end of the century, it is at the depth of 5 miles, it was, at the end of the fourth year, at a depth of only 1 mile. Then, a mass of rock, 10,000 feet below the surface, would be nearly a mile deep in the zone of tension. Possibly this may explain the mineral banding of much of our older granitoid rock, already mentioned, and the coincidence of foliation with what appears to be stratification in the later Archæan schists, as well as the certainly common coincidence of microfoliation with bedding in the oldest indubitable sediments.

Pressure, no doubt, has always been a most important factor in the metamorphism of rocks ; but there is, I think, at present some danger in over-estimating this, and representing a partial statement of truth as the whole truth. Geology, like many human beings, suffered from convulsions in its infancy ; now, in its later years, I apprehend an attack of pressure on the brain.

The first deposits on the solidified crust of the earth would obviously be igneous. As water condensed, denudation would begin, and stratified deposits, mechanical and chemical, become possible, in addition to detrital volcanic material. But at that time the crust itself, and even stratified deposits, would often be kept for a considerable period at a temperature similar to that afterwards produced by the invasion of an intrusive mass. Thus not only rocks of igneous origin (including volcanic ashes) would predominate in the lower foundation-stones, but also secondary changes would occur more readily, and even the sediments or precipitates should be greatly metamorphosed. Strains set up by a falling temperature would produce, in masses still plastic, banded structures, which, under the peculiar circumstances might occur in rocks now coarsely crystalline. As time went on, true sediments would predominate over extravasated materials, and these would be less and less affected by chemical changes, and would more and more retain their original character. Thus we should expect that as we retraced the earth's course through "the corridor of time," we should arrive at rocks which, though crystalline in structure, were evidently in great part sedimentary in origin, and should beyond them find rocks of more coarsely-crystalline texture and more dubious character, which, however, probably were in part of a like origin ; and should at last reach coarsely-crystalline rocks, in which, while occasional sediments would be possible, the majority were originally igneous, though modified at a very early period of their history. This corresponds with what we find in Nature, when we apply, cautiously and tentatively, the principles of interpretation which guide us in stratigraphical geology.

I have stated as briefly as possible what I believe to be facts. I have endeavored to treat these in accordance with the principles of inductive reasoning. I have deliberately abstained from invoking the aid of "deluges of water, floods of fire, boiling oceans, caustic rains, or acid-laden atmospheres," not because I hold it impossible that these can have occurred, but because I think that this epoch in the earth's history so remote and so unlike those which followed, that it is wiser to pass it by for the present. But unless we deny that any rocks formed anterior to or coæval with the first beginning of life on the globe can be preserved to the present time, or, at least, be capable of identification (an assumption which seems to me gratuitous and unphilosophical) then I do not see how we can avoid the conclusion to which we are led by a study of the foundation-stones of the earth's crust—namely, that these were formed under conditions and modified by environments which, during the later geological epochs, must have been of very exceptional occurrence. If, then, this conclusion accords with the results at which students of chemistry and students of physics have independently arrived, I do not think that we are justified in refusing to accept them, because they lack the attractive brilliancy of this or that hypothesis, or do not accord with the words in which a principle, sound in its essence, has been formulated. It is true in science, as in a yet more sacred thing, that "the letter killeth, the spirit giveth life."—*Nature.*

## A NEW PLUMBERS' TRICK.

The *Sanitary News* describes a new plumbers' trick, which has been first discovered in Milwaukee, but may be known elsewhere, so that architects and inspectors will do well to be on their guard against it. In Milwaukee, as in many other towns, all soil pipes put up in dwelling-houses must be tested by filling them with water. A certain firm, knowing that a defective pipe had been used, contrived to plug it with clay, so that the water applied for testing it did not enter the pipe at all. It was not stated how the inspector happened to find out this ingenious deception, but plumbing inspectors become wonderfully expert in observing suspicious indications, and the offending firm was reported, and punished by having its license revoked until the defective pipe should be replaced by a new one. Most persons will say that the revocation of the license ought to have been made permanent.

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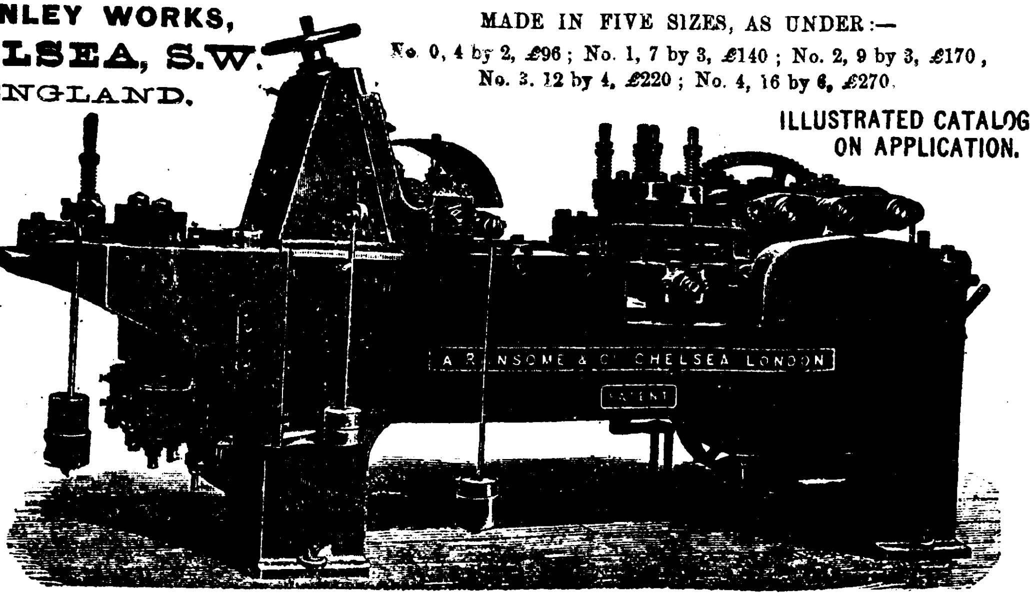
[*] The lowest temperature, which, so far as I know, has been observed in lava (basic) while still plastic, is 1228° F.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