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PROSPECTUS FOR 1883.

CANADIAN MAGAZINE

OF

Science and the Industrial Arts.

PATENT OFFICE RECORD.

EDITOR—HENRY . BOVEY, M.A. (Camb.), Associate Memb. Inst. C.E.; Memb. of Inst. M.E. (Eng.) and American Inst. M.E., Professor of Civil Engineering and App. Mechs., McGill University.

Vol. 11. JANUARY, 1883. No. 1.

THE PROPRIETORS have great pleasure in informing the Subscribers to the SCIENTIFIC CANADIAN, and the Public in general, that arrangements have been made by which PROF. BOVEY will undertake the editorship of this Magazine at the beginning of the New Year, when the name of the publication will be changed to the *Canadian Magazine of Science and the Industrial Arts.*

Every effort will be made to render the publication a useful vehicle for the conveying of information respecting the latest progress in Science and the Arts.

It is hoped that the MAGAZINE will also be a medium for the discussion of questions bearing upon Engineering in its various branches, Architecture, the Natural Sciences, etc., and the Editor will gladly receive communications on these and all kindred subjects. Any illustrations accompanying such papers as may be inserted will be reproduced with the utmost care.

The First Number will contain, among others, articles on Technical Education by J. CLARKE MURRAY, L.L.D.; on Cable Traction for Tramways and Railways by C. F. FINDLAY, M.A., Associate Memb. Inst. C.E.; and on the Transit of Venus by ALEXANDER JOHNSON, LL.D.

A space will be reserved for Notices and Reviews of New Books, and Resumès will be given of the Transactions of various Engineering and Scientific Societies.

The PATENT OFFICE RECORD will continue to be a special feature of the Magazine; and will be published as an Appendix to each number. The Illustrations, however, of the New Patents will be considerably enlarged, so that each invention being more easy to examine will be made clearer and more intelligible to the general reader. This RECORD gives information of the greatest value to engineers, manufacturers, and to all persons interested in the different trades.

In view of these great improvements the subscription price will *only be $2.50, payable in advance,* and it is confidently anticipated that a large increase will be made in the number of subscribers.

The efficiency and success of the Magazine, the *only one of the kind in Canada, must in a great* measure depend upon the hearty co operation and support of the Public.

NOTE.—All communications relating to the Editorial department should be addressed to the Editor, 31 McTavish St., Montreal.

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TECHNICAL EDUCATION.

BY J. CLARK MURRAY, LL.D.

About a century ago Samuel Johnson declared that "education was as well known, and had long been as well known as ever it could be." This effervescence of his habitual dogmatism was excited by the appearance of a new treatise on education; but in spite of the impatience with which the subject was thus dismissed long ago, the world in general find that a great deal remains to be said on it, which is calculated to interest still. Among the questions which continue to be discussed in connection with the subject, there is one which becomes more complicated every year by the perpetual increase in the range of studies over which education may extend. It is common to distinguish the studies of an educational course into two classes according to the immediate ends which they have in view. Some studies look merely to the character of the person who is being educated, and their chief end is simply to develop to a state of vigour the powers with which he is endowed, so that he may be able to apply these effectively to any duties to which he may be called in life. These are what are commonly understood by *liberal* studies. There is another class, however, whose primary object is to communicate to the student such special training as may fit him for the particular occupation in which his life is to be principally spent. Such studies are distinguished as *professional.*

No one denies the essential importance of liberal culture in human education; but it has been too often assumed that the necessity of liberal culture requires us to exclude all professional considerations, or at least justifies us in restricting an educational course, either wholly or mainly, to studies that can never be of any service in the subsequent occupations of life. It must, of course, be acknowledged that many studies, like some controversies in mediæval metaphysics, which are comparatively trivial in positive worth, may yet, by the enthusiasm of the scholar, be made the means of developing a high degree of intellectual acuteness and power; but there is no reason to suppose that an equal culture might not be obtained in the study of sciences which admit of innumerable applications to the security or the enjoyment of life. It is, therefore, worthy of consideration, whether strictly professional studies might not receive a more prominent recognition, even in those academical regulations which aim merely at liberal education.

But whatever may be the value of professional studies in a system of liberal education, for professional purposes they are, of course, altogether indispensable. Now, among professional studies an obvious distinction may be drawn. Some of the occupations of life have a permanent material product in view; and the education which is designed to prepare for these, is commonly distinguished by the term *technical,* when used in its most restricted sense. *Technical* is originally a Greek word for *artificial,* and therefore it describes appropriately any process by which the art of man transforms a product of nature. Now, all such material products of human art imply the use of a material instrumentality,—a tool, a machine, or other apparatus, as well as the raw substance which is to be transformed. Accordingly, all technical education implies a training in the use of such instrumentality,—a practical knowledge of the natural properties by which it is rendered serviceable to man.

It is too often forgotten that the primitive instrumentality of man,—the instrumentality, without which all others are valueless,—is his own physical organism. Again an etymological reminder may not be out of place: *Organ* is merely a Greek word for *instrument.* The technical education of men ought therefore, to begin with the training of their bodily organs. The hand is, of course, the organ chiefly—in fact, almost exclusively—employed in the production of human art. We *handle* our tools and machinery; we *manipulate* our apparatus; and all our productions even when elaborate machinery is employed, are described as *manufactures,* as if made entirely by the hand. The psychologist and the anthropologist alike know the value of this organ in discovering the mechanical forces of nature, and in making them subservient to the human will. Since the time when, twenty-three centuries ago, Anaxagoras declared that "man is the most intelligent of animals because he has hands," it has been evident to science that there is no other external organ of the body, in which we stand so decidedly superior to the lower animals. For the general purposes of human life, therefore, an education must be defective, which overlooks altogether the training of the hand; and it may be fairly pleaded that such a training ought to form a part of even a purely liberal culture. One may accordingly join with full sympathy in the lamentations of Mr. Ruskin and others over the neglect of manual skill, even though one may refuse to charge it upon the extended use of machinery, or to encourage a retrogade movement which would require men to produce by the hand articles which a machine can turn out at immeasurably less cost of labour, and with more certainty of mechanical exactness. The very instrumentalities, which human art employs in its productions, give plenty of scope for skilful handling, and demand therefore an education which shall refine the sensibility of the manual muscles. Fortunately this is a training which may be begun even in the nursery, and does not exact that unnatural stimulation of the brain, which exerts such disastrous results on the general health by prematurely adopting other modes of early education. The exercise of his little mind in the intelligent direction of a tool is a kind of labour on which the child is always ready to enter with zest, and therefore with little chance of unnaturally overstraining any of his powers. Every opportunity may therefore be wisely afforded to gratify the childish craving for the use of pen and pencil and brush; and even the handling of sharp-edged tools may, with some simple precautions, be profitably encouraged at a very early age.

All the instruments, which man employs, are but embodiments of natural forces, and all the forces of nature work in accordance with invariable laws. To use an instrument, however clumsily, in the production of any object, implies at least some vague knowledge of the laws governing the forces that are embodied in the instrument, but perfect accuracy in the operation, and certainty as to its result, can be attained only when a vague knowledge has made way for exact science. Even the common tools, which have been the familiar benefactors of man from a period anterior to the dawn of history, depend for their efficiency upon the accuracy of his knowledge regarding the properties of matter, by which they work their results.

The advance from stone implements to bronze, from bronze to iron and steel, by which the progress of civilization has been marked, is indicative of man's increasing acquaintance with the force of the material world.

If even the simplest instrumentalities, without which human life could scarcely be rendered endurable, derive an increased efficiency from the exactness of the science with which they are used, it is evident that there must be an infinitely larger sphere and a more imperative demand for such exactness of science in the use of the complicated machinery, which has expanded to its enormous proportions the industrial production of our day. It is a fact which is remarkable, although on reflection not unintelligible, that the extended application of machinery, instead of lessening the demand for skilled labour, has only led to increased requirements in reference both to its quantity and its quality. To handle a complicated machine even with safety, requires a considerable amount of technical skill; to work it with economy, requires still more; and the deplorable accidents, as well as the deplorable waste, by which industrial occupations have been in the past, and still are in many cases, accompanied, are generally due to inadequacy of technical training rather than to any moral want of conscientious care.

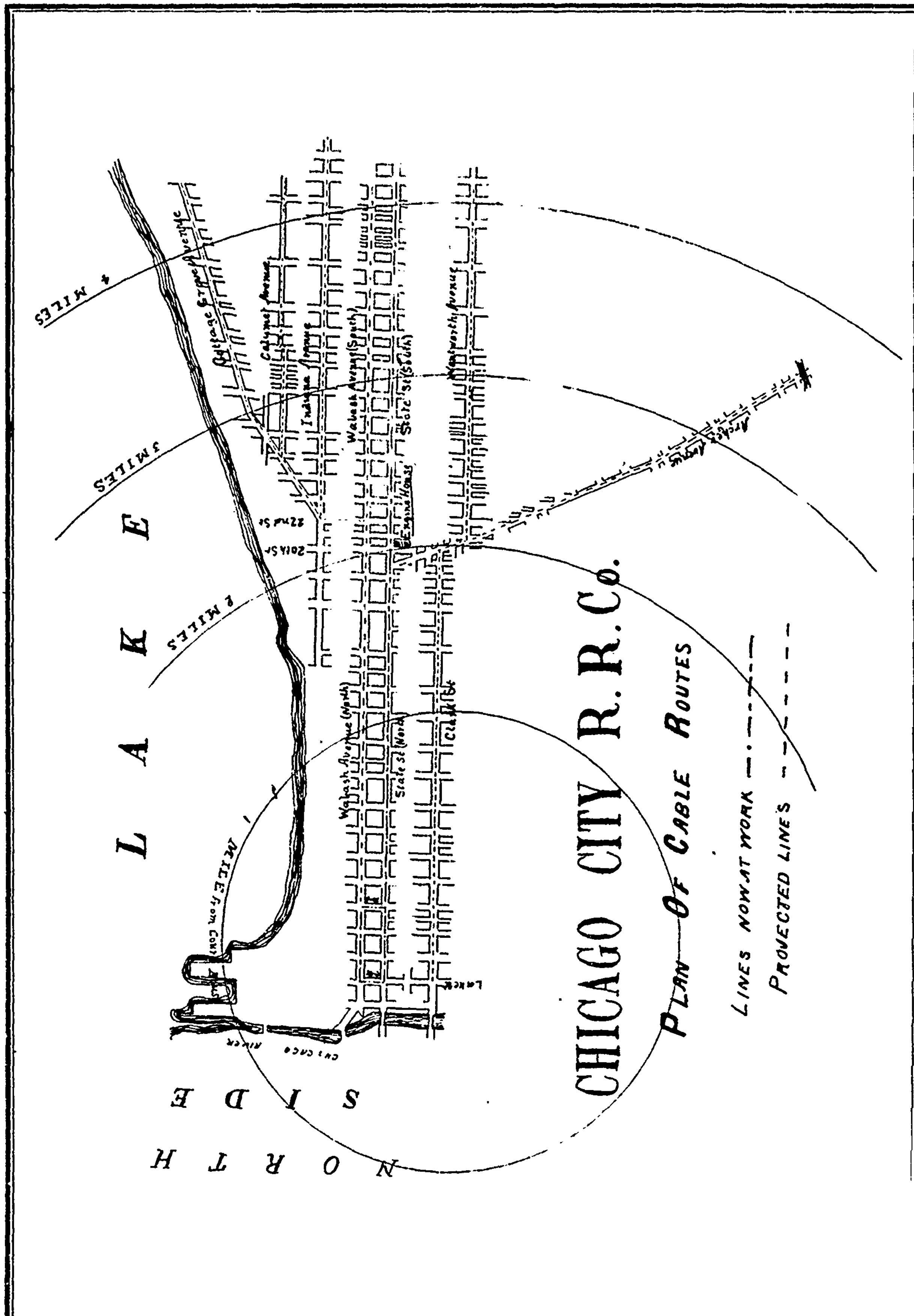
The accidents, arriving from ignorance of the forces at work in the machinery and materials of modern industries, are suggestive of a fact involved in the complicated civilization of our time. In consequence of the numerous and elaborate applications of practical science to the conveniences of human life, men are becoming more and more dependent on each other for the advantages of the technical knowledge which they severally possess. Accordingly the enjoyment of the very benefits, which science is conferring on mankind, renders it every day more and more imperative that those, who profess to perform any work, shall be adequately equipped for performance by a previous technical education. The vast increase, which the last few years have witnessed, in schools of technology, and in the numbers of men eager to obtain their advantages, affords a reasonable ground for the hope that a technical preparation will, in the near future, become a compulsory provision for all the more important industries of human life.

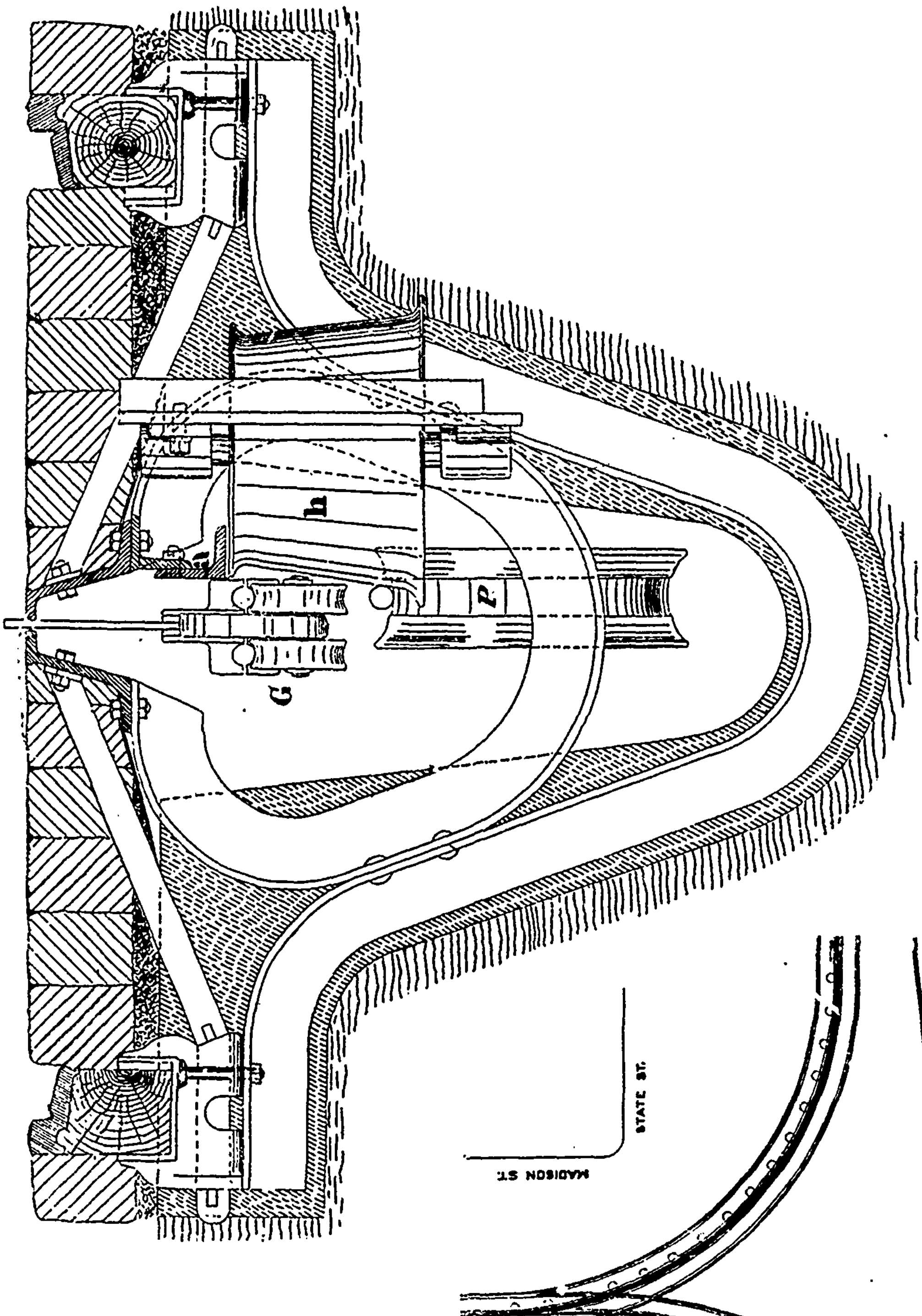
CABLE TRACTION FOR TRAMWAYS AND RAILWAYS.

BY C. FARQUHAR FINDLAY, M.A., C.E.

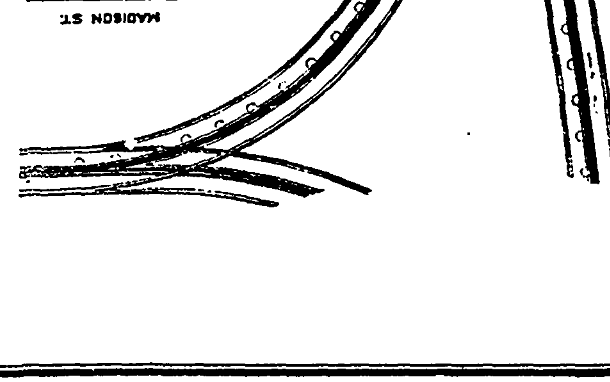
TRACTION by means of a rope and stationary engine was the way in which steam power was first applied to locomotion, though it is only recently that it has been utilized for passenger transport on a large scale. George Stephenson's opponents went so far as to maintain that no locomotive engine could be made which would haul its own weight up a moderate grade even without any cars attached. The triumph of the locomotive has however been so complete, and its manufacture has been brought to such a pitch of perfection, as to blind even those most accustomed to study the broader aspects of such questions to the fact, that there are special cases, and those of the greatest importance, in which a stationary engine and cable have an immense economical advantage over any form of locomotive, besides being free from many of its objectionable features. The case of most common occurrence to which cable traction is applicable is that of a road of moderate straightness on which there is a traffic requiring cars at frequent intervals. Not to go here into details, there are two great sources of economy in the cable system as compared with any kind of locomotive, steam, electric or other; firstly, the avoidance of all the dead weight hauled over the road in the shape of engines, boilers, etc., and otherwise required in order to give sufficient adhesion to the driving-wheels of the locomotive. In the case of a street railroad operated by any form of locomotive it would be a fair case to suppose a car weighing with its full complement of 30 seated passengers 12,000 lbs., to be drawn by a locomotive weighing 12,000 lbs. By getting rid of the locomotive we should here save 50 per cent. of the total weight hauled over the track; in other words the mass moved would be reduced from 800 lbs. per passenger to 400 lbs., etc., and the only corresponding increase would be the weight of the cable itself, which is trifling in comparison and carried in a cheaper way, viz., by pulleys with fixed bearings. The second saving is in substituting stationary engines and boilers, with the modern coal-saving appliances, for a number of locomotives. Where cars run at intervals of a few minutes the saving from these causes is so great that the consumption of fuel with a stationary engine and cable would not be more than 1-10th of what locomotives would take to do the same work, and possibly a good deal less. As, in most parts of the world locomotive traction is cheaper than animal traction, the economy of the use of the cable over the use of horses or mules would be equally great under favourable circumstances.

This being the case, the question will be naturally asked how it comes to pass that a means of traction apparently so simple and straightforward is only now coming into any general use. The answer is that there are two practical difficulties to be confronted in adopting cable traction, which have until recently seemed to be prohibitive. First, the case, as before said, to which cable traction is most markedly applicable is that where a frequent succession of cars or trains has to be run. In any special case by studying all the circumstances it could be determined just what frequency of cars would make cable traction cheaper than that by animals or locomotives, but probably with moderate grades, and circumstances otherwise ordinary, cars must be run at a headway of somewhere between 5 min. and 15 min., to give the economical advantage to the cable. Now this case only arises in the streets or suburbs of a large city and this is just the case where a running cable, except far overhead, or concealed underground, would be impossible, because of the other traffic along or across the road. Secondly, no practical means were ever known by which a car could be so attached to an endless moving cable that the car could start and stop at will, without jerk, unless the cable were stopped also. The first of these difficulties would be avoided by making use of the modern idea of the elevated railroad to which we shall have to refer hereafter, but this would not meet the requirements of our cities except in special cases. The first intimation of the practical solution of the problem, as regards ordinary street travel, of which we have any knowledge is contained in a patent granted in the United States to


CHICAGO CITY R. R. Co.
PLAN OF CABLE ROUTES
LINES NOW AT WORK
PROJECTED LINES
LAKE
NORTH SIDE
4 MILES
3 MILES
2 MILES
Cottage Grove Avenue
Calumet Avenue
Indiana Avenue
Wabash Avenue (South)
State St (South)
Wentworth Avenue
Archer Avenue
22nd St
20th St
Wabash Avenue (North)
State St (North)
Clark St
Lake St
Chicago River



Section of Track at Curve.
FIG. 2
Scale, $1\frac{7}{8}$ in = 1 ft.



PLAN OF CURVES AND CROSSING.

E. S. Gardner, of Philadelphia, in 1858, in which he proposes to construct, between the tracks of a city railroad, a tunnel, along the crown of which is a slot open to the street. In this tunnel is to be carried, on pulleys, an endless moving rope to be connected with the car by a machine passing through the slot. He does not specify the construction of this machine. The means of overcoming the second difficulty were, in principle, first put forward, as far as we know, by Gen'l Beauregard of New Orleans, who in 1869 patented a form of grip, for use in connection with an overhead travelling rope, in which there were two jaws enclosing the rope and by closing the jaws on the rope or opening them, the car which carried the grip, would move with the rope or stand still letting the rope pass freely through. Beauregard's invention was put in operation at New Orleans but never became a practical success and from his patent he would not appear to have understood the novelty and value of this feature in his Grip, viz., the jaws controlled from the car to clutch and rel‘ se the cable at will. Probably in the form his railway took—with the cable carried like a telegraph wire on poles above the car—the grip will never be used, but the simple idea it contains which we have just mentioned, taken along with the equally simple idea of Gardner's patent, form the only absolutely essential features of the cable system as now in use on street railroads.

The details of the methods in which these two principles are applied may be endlessly varied and have probably not yet reached their final form, for, like many other valuable inventions, they have not received any attention from scientific engineers till their success has been already established Probab'y Gardner's underground cable was ridiculed twenty years ago as much as the "movable sidewalk" or any other of the thousand and one fanciful inventions patented every year.

The first successful application of the cable to street use was on the Clay St. Hill R. R. of San Francisco, of which Mr. A. C. Hallidie is president. This road is too steep to be successfully worked by horses, and Mr. Hallidie conceived the idea of applying to it some modification of the wire rope railways in common use for transporting ore from mines for shipment, placing the rope in an underground tube as in Gardner's proposed plan. The enterprise appears to have met with a good deal of discouragement, as was only natural perhaps, from its novelty, but Mr. Hallidie has convinced his friends of the practicability of the scheme and after a good deal of delay it was finally opened in 1873 and met with the success it deserved for the pluck and enterprise displayed in the undertaking. No sooner was its success practically established than other lines of the same kind were built on the steep hill sides over which San Francisco spreads, and the economy of the system over horse traction became so evident that, one by one, the horse railroads on the more level streets were converted into cable roads. Mr. Hallidie's ideas, however, were discarded on most of these roads both in the construction of the tube and the design of the grip. Other inventors came out with improvements on the Clay St. Hill plans and a good deal of litigation ensued. We are not going to enter on the unprofitable discussion of questions of priority of invention, and indeed it is at present impossible for us to do so even if we wished to decide some of them. It is an undoubted fact that Mr. Hallidie patented the first grip that was ever used with practical success for a cable road of this kind, and also that he deserves great credit for the persistence with which he u ged the construction of the Clay St. Hill Ry., and probably his merits as one of the pioneers of the system would not have been disputed but for the fact that he has denied to others engaged in the same work, any share of credit for its success and has put forward utterly untenable claims to control by his patents the system of traction by means of an underground rope used in any way whatever. A hundred inventors have been at work since 1873, and though most of their inventions, like most inventions of other kinds, are useless, yet some of them are undoubtedly superior to Mr. Hallidie's inventions for the same purpose and do not involve anything discovered by Mr. Hallidie. Mr. Hallidie can only control the cable system, we may be sure, by possessing not the earliest but the best inventions on the subject and the credit of having built the first road of the kind will not help him much unless he can build better roads than other people. The most important step in the development of the system of cable traction was the adoption of it by the Chicago City Railway Co. which operates 50 miles of road and carries more passengers than all the San Francisco roads together. In the summer of 1880 they constructed tunnels for a double track cable road in State St., running from the centre of the city to a distance of four miles southwards. Engines and machinery were at the same time designed for the subsequent working of cables on all their lines from a single station about the middle of the State St. line.

An engineer who had been engaged on some of the San Francisco roads was employed to carry out the work, and in most respects, it has been a decided success. We give illustrations of the work on pages 1, 5, 8, and 12, comprising a view of the grip and a section of the roadway showing the construction of the tunnel. The grip is different in some respects from any previously used and is probably the best yet introduced, though still not perfect in its action. The most notable advance in the application of the system made at Chicago is the use of the cable on curves. At San Francisco the roads were all straight except one, where at a short curve the cars released the cable and running round by their acquired momentum picked it up again on reaching the tangent line. At Chicago, on the other hand, the cars pass on a loop round several blocks, to pass from one track to the other without switching. The curves are of 45 ft. radius, and on this "loop" there is a separate cable travelling at half the speed of the State St. cable and driven by it. It is found that the cars can be operated on this part of the line as well as on any other.

The only other company that has adopted the cable system so far is the Union Passenger Ry. Co. of Philadelphia which has built a line about a mile and a half in length in the outskirts of the city near Fairmount Park, as an experimental piece, preliminary to introducing it in Market St., the chief street of the city, next summer. Their plans are almost entirely different to any previously tried, their grip being a new one, and their tunnel simply made of a cast iron tube 12 inches in diameter. At the time of writing, this road is not yet at work, but we believe the company has fully decided to introduce the system on Market St. next year, though the plan of their present road will probably be found to need some modification under the test of actual practice. Other companies are contemplating the construction of cable roads shortly and a strong company has been formed in London to introduce the system in Europe. In proceeding now to consider a few of the points of interest involved in this system of traction, the most important one and that which governs more than any other the success of the road is the grip, as it has come to be technically called. In the earlier forms of grip used in San Francisco the rope was grasped between pairs of rollers. In these afterwards introduced, as in that used at Chicago, the rope is grasped between surfaces of some considerable length, in some cases of metal and at Chicago of wood. It is claimed that the wires of the cable are injured by the application of so much pressure as is required on the small portion of the cable which can be brought into contact with the edge of a roller. Rollers are introduced in the Chicago grip for the purpose of carrying the cable when the car is standing still and the cable running through the jaws. This is required because the grip has to carry the weight of a considerable length of the cable, travelling as it does, some inches above the normal level of the cable. Another difference between the various grips in use is that Hallidie's grip, and many other patented grips, are so constructed as to be able to descend and pick up the cable at any point on the road, while others, including the Chicago grip receive the cable at the beginning of the journey and retain it throughout, whether moving or still, and have no provision for recovering the cable if once lost. Such provision is not found to be requisite and without it the grip is much simplified in construction. The weak point in the Chicago grip is the uncertain action of the device adopted for getting rid of the cable at the end of the journey. This is done by spools which will be seen in our illustration at each end of the grip. They are raised by a catch with the upper jaw of the grip when the operating lever is moved right to the end of its stroke. They sometimes fail to eject the cable from the grip and the worst features of it is that the driver has no means of knowing whether this is so or not and in this way when the road was first opened the cable was cut in two several times, causing a delay of many hours for splicing. Since then, at each place where a cable has to be dropped, a manhole is kept always open and a man is stationed to watch whether the cable is dropped or not, so that if not, the car can be stopped. This is not a satisfactory state of things, and in some cities it would not be permitted to have a manhole constantly open in the middle of the street, but there is no doubt that a mechanical device can be found which will effect the required object with certainty and then this grip will be all that can be desired.

(To be continued.)

ON HYDRAULIC LIFTS FOR PASSENGERS AND GOODS.

BY MR. EDWARD BAYZAND ELLINGTON, OF LONDON.

(A paper read before the Institution of Mechanical Engineers, England.)

It is only within the last ten or fifteen years that Lifts worked by mechanical power have come into general use, and, excluding docks and railway goods stations, it is still rather the exception than the rule to find power lifts in public buildings, or in warehouses and hotels even of considerable size. The greatly increased value of land in large towns, and the consequent increased height of the buildings erected, render however some kind of mechanical lifting power essential to the comfort and convenience of the occupiers.

Accidents to lifts, especially when worked by mechanical means, have been so frequent that many hesitate to adopt them on account of the risk involved. But in a rapidly increasing number of cases their use is a necessity, and the risk must be taken. It becomes therefore a question of public importance that the risk should be reduced to a minimum.

In determining the question as to the best kinds of lift for passengers and for goods, it is necessary to premise that whatever system of lifts is proved to be safest and best for passengers should also be adopted, where practicable, for goods. Workmen and others are in the habit of travelling in goods lifts, and a prohibition against this practice is productive of inconvenience. Considerations of expense however will often stand in the way of the adoption of the safest kind of lift for goods alone, especially when the height of lift is great; and there is in consequence a demand for two standard types, one for passengers and another for goods.

CHAIN LIFTS.

The first rudiment of a lift is to be found in the Hoisting Jigger, as commonly used in the Liverpool cotton warehouses: this consists of a winding drum, a cat-head pulley, and a chain attached to the article to be raised, as shown in Figs. 1 and 2, Page 9. By adding a cage and a guide to the chain, the apparatus has been developed into a lift. It is worked either by winch handles A, Fig. 2, or from a lower floor by the endless rope B. There are not many persons who would risk being hoisted in a sling to a considerable height; but when a cage is attached, the temptation to avoid the labour of ascent becomes great, and the individual enters, unwittingly staking his life on the security of the chain or rope supporting the cage.

Various attempts have been made to reduce or eliminate this risk. The favourite plan is to insert, above or below the cage, a safety apparatus, to retain the cage in position in case of the breaking of the chain or rope. Every few months a new safety apparatus crops up, always the most perfect that was ever invented, and warranted to stand the severest tests that can be applied. The apparatus is tested, and is found to work admirably, to the delight of the unfortunate victims who are to use it. A few years after an accident happens, and in the majority of instances, the safety apparatus is found to be a delusion; generally for the simple reason that no apparatus which is not in constant and necessary use is likely to be kept in proper working order. Moreover no safety apparatus with which the author is acquainted provides against all possible accidents to the machinery. Reasonable safety must be secured by some other means.*

* In one of a series of articles on "Elevators" in the American *Architect and Building News*, 1880, the following suggestive passage occurs:—"It is impossible to be too careful in the inspection of these appliances (viz., safety catches), whose action is very uncertain under the various unfavourable circumstances of actual use. Out of eleven elevators whose fall was reported during the month preceding that in which we write, it is said that only two were unprovided with what purported to be safety catches." Wire rope lifts are chiefly used in America.

CABLE ROADS.

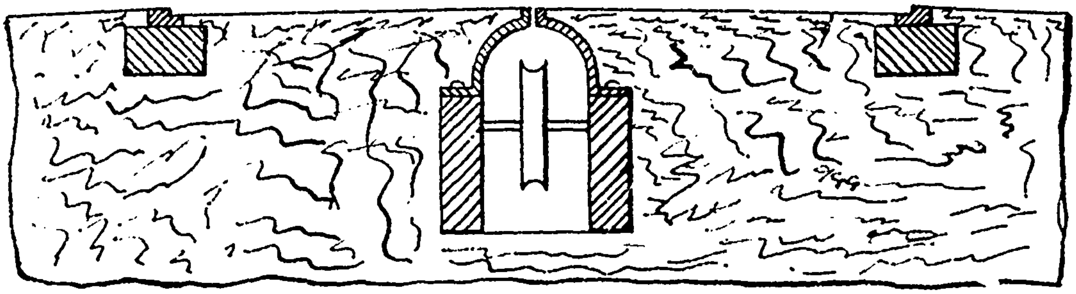
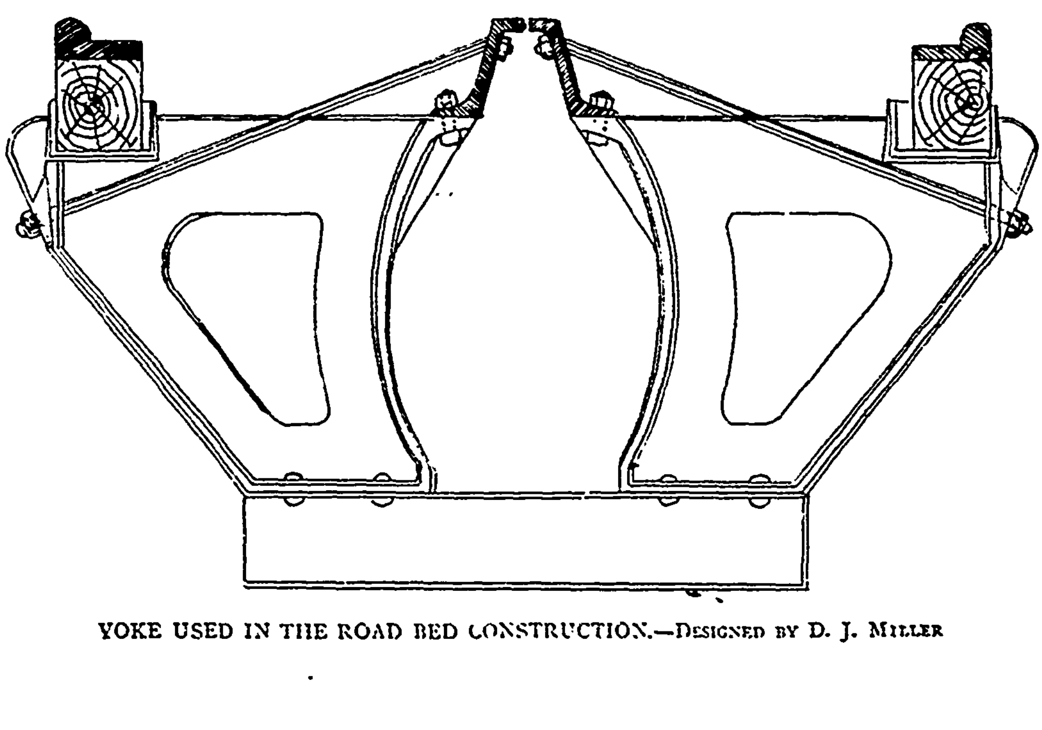
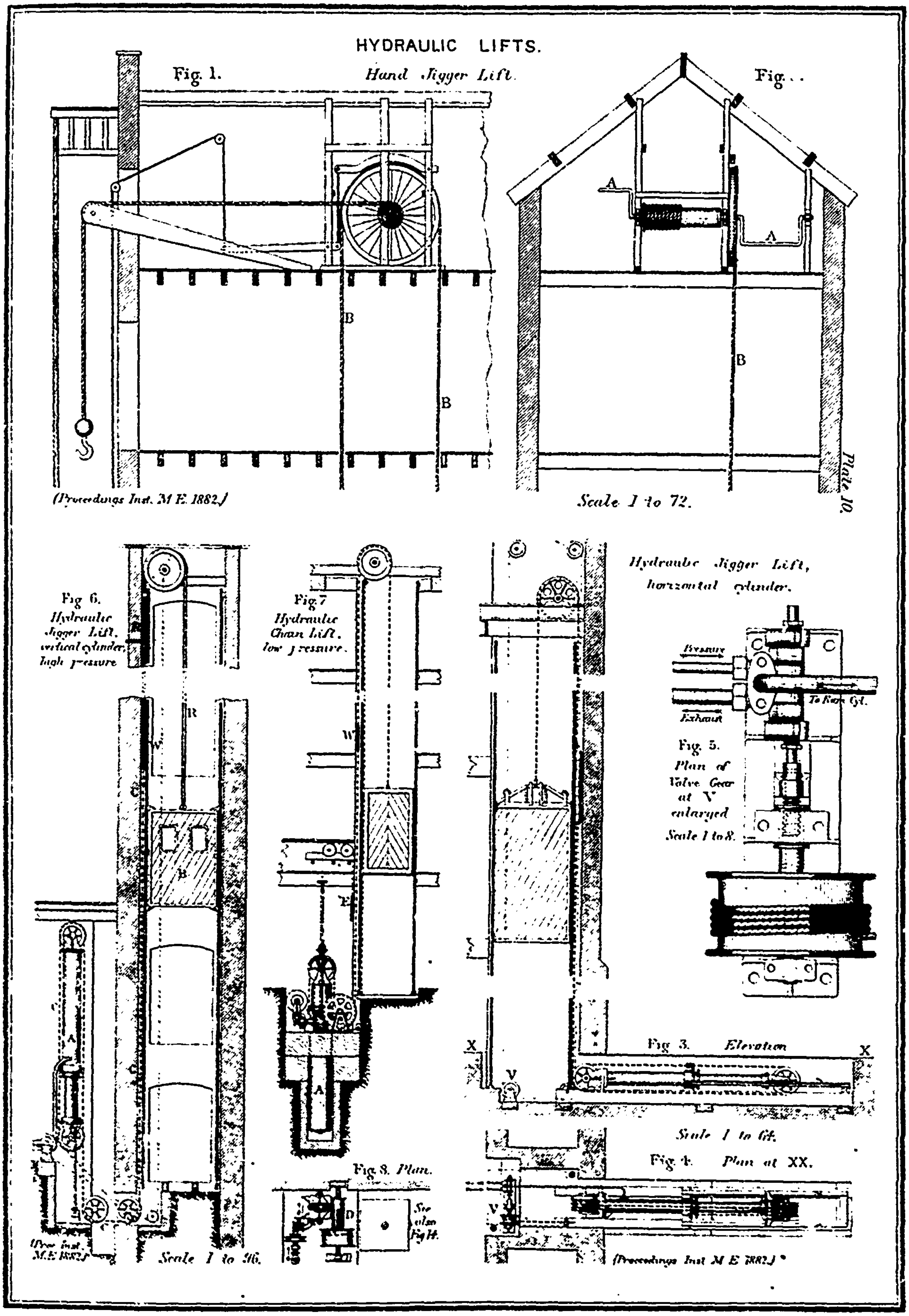


Fig. 10.—GARDNER'S PATENT OF 1858.



YOKE USED IN THE ROAD BED CONSTRUCTION.—Designed by D. J. Miller


HYDRAULIC LIFTS.
Fig. 1. Hand Jigger Lift.
Fig. .
(Proceedings Inst. M E. 1882.)
Scale 1 to 72.
Plate 10.
Fig 6. Hydraulic Jigger Lift, vertical cylinder, high pressure
Fig. 7 Hydraulic Chain Lift, low pressure.
Hydraulic Jigger Lift, horizontal cylinder.
Pressure
To Ram Cyl.
Exhaust
Fig. 5. Plan of Valve Gear at V enlarged Scale 1 to 8.
Fig 3. Elevation
Scale 1 to 64.
Fig. 4. Plan at XX.
Fig 8. Plan.
See also Fig 14.
(Proc Inst. M.E 1882)
Scale 1 to 36.
(Proceedings Inst M E 1882)

In a chain hoist of any kind (where the word chain must be taken to include a hemp or wire rope), the first thing is to be sure of the chain or rope. If a chain be used, it should be of such strength that the ordinary load would not straighten the link out, even if it were cracked through. If wire ropes are used, there should be two, each capable of doing the whole work. The next point is the attachments. The author's experience is that more accidents arise from the breakage of the attachments than of the chain. The attachments should be considerably stronger than the chain, and, where practicable, should be tested with it.

Having secured a good chain and attachments, the next question is as to the safety of the mechanism by which the chain is hauled in, and the cage lifted. There is a certain risk attached to a chain or wire rope, which cannot be removed; but it will obviously depend upon the mechanism adopted whether other risks are super-added. The chain may be hauled in by machinery worked by hand, steam, air, gas, electricity, or water; but there is generally very little distinction to be drawn between the machinery used with the first five of these motive powers,—given the gear, it is simply a question as to what force shall drive it.

Accidents may happen to any of the mechanisms adopted, and some of the elements of risk, with these various sources of power, may here be mentioned

(*a*) Hand-power lifts are generally fitted with a brake apparatus, made up of several pieces, the giving way of any one of these would probably send the cage down with a run.

(*b*) The steam or air engine, in addition to the risk of breakage in the brake mechanism, is liable to breakage in the engine itself, and also in the gearing through which the power is usually transmitted, while the common practice of having clutches to throw the wheels in and out of gear adds a further risk of accident. Steam power is safer where worm gearing is adopted, and where steam is used for lowering as well as lifting, but this involves a great waste of power. In steam lifts there is also a considerable danger of accident from overwinding.

(*c*) The gas engine has all the risks attending the use of hand or steam power, and others besides; since, owing to the peculiar intermittent nature of its working, gearing is unsuitable for the first motion, and straps have to be used, which of all transmitters are the most dangerous. In a lift worked by a gas engine therefore, in addition to the necessary risk of a chain, there is the risk attending the use of driving straps and gearing in the working crab, and of brake gear, the possibility of overwinding, the comparatively long time occupied in starting and stopping, and also the extra strain on the whole of the mechanism due to the shock of the explosions.

(*d*) The application of electricity to hoisting is at present only in its infancy; but so far as attempts have yet been made to obtain motive power by this means, its application would appear to be subject to the same defects as the other methods that have been considered.

(*e*) Finally there remains hydraulic power; and it is obvious that one source of risk is at once removed by employing water-pressure, namely, that caused by the use of a brake apparatus, since in a hydraulic lift the descent is regulated by the speed at which the water used in lifting is allowed to exhaust. Water-power may be employed to haul the lifting chain through toothed gearing, or by means of straps, in which cases there still remain some of the risks inherent in the other systems, but by suitable arrangements all such mechanisms may be avoided, and the motive power may be obtained without in any way increasing the risk inherent to the use of a chain. This condition of relative safety is only obtained by taking care that the pressure of water on the hydraulic ram is directly transmitted to the hoisting chain. If the power is so applied, any derangement of the mechanism would either mean the stoppage of the lift, or its gradual descent owing to the escape of water from the lift cylinder. In the possible case of a burst cylinder or pipe, the same condition would hold good; while the friction of the ram in the stuffing box would in itself perform the function of an automatic brake, in case of the too sudden escape of the contained water. The ram should also be provided with a positive stop, to prevent overwinding. The perfection of control obtained in hydraulic lifts is a further important element of safety. A single valve suffices for the control of all the motions of such lifts.

The form of hydraulic lift which most perfectly fulfils the above conditions for a chain hoist is that introduced by Sir William Armstrong and known as the Hydraulic Jigger. Figs. 3 to 6, Page 9 illustrate this, the simplest type of a high-pressure hydraulic chain lift. In Figs 3 and 4 the cylinder is horizontal, and the working pressure is therefore constant. There is a loss of effect in this hoist, in consequence of the weight of the chain being balanced when the cage is at the bottom, and unbalanced when the cage is at the top. This loss might be partially avoided by placing the cylinder vertical and making the ram work upwards, but this would involve balancing the ram, otherwise it would increase the risk of accident; for, if the cage got fast, and if the valves were open to the exhaust, the ram might descend without the cage, and the cage might afterwards become suddenly released and fall. The lifting chain is sometimes balanced by letting the cage carry a loose chain below, which is coiled on the ground when the cage is at the bottom, and which is picked up by the chain as it ascends.

Fig. 6, Page 9, is an illustration of a hydraulic jigger hoist suitable for moderate pressures. The ram A is inverted, and its weight partly balances the weight of the cage B. The chain C is attached at one end to the cylinder, at the other to the counterweights W. From the counterweights two wire ropes R are led to the cage, each being of sufficient strength to carry the weight. The author's experience is that wire ropes are not so reliable as chains, and that it is desirable where practicable to use duplicate ropes. In this hoist it will be observed that, owing to the inverted position of the ram, there is a greater head of water at the end of the stroke than at the commencement. But, as the lift is constructed, there is no loss of effect from this cause; for, the chain being more than twice the weight of the wire ropes, this extra weight assists the ascent of the cage at the commencement of the stroke, and thus compensates for the variation in head of water.

The hydraulic jigger is not generally applicable except for high working pressures; and high pressure water is only occasionally available. Unfortunately therefore it is often necessary to depart from the beautiful simplicity of the apparatus. The best arrangement in such a case is to adhere to the hydraulic cylinder and ram, but to introduce a second chain into the multiplying gear. By doing so there is the additional risk due to the second chain and its attachments; but this extra risk is far less in proportion than that of the lift chain itself, owing to the diminished speed and greater absolute strength of the first motion chain.

Figs. 7 and 8, Page 9, illustrate a low-pressure hoist, suitable for pressures of 25 to 50 lbs. per sq. in., constructed as above described. In dealing with such low pressures it is essential to economy to save every foot of head, and to be very careful in the arrangement of the pipes, so as to avoid unnecessary bends. By putting the cylinder A below ground, and letting the ram work vertically upwards, the greatest economy is secured. The whole of the available head is then utilized, and the extra head of water at the beginning of the stroke of the ram compensates for the extra weight of the lifting chains which have then to be raised. It is necessary to balance the weight of the ram by counterweights B, both to save power, and also to ensure the ram being pulled down by the descending cage, and so to prevent the possibility of an accident from the cage sticking fast. The winding drum C of this hoist has two diameters, as shown in Fig. 14, Plate 14; on the smaller is coiled the lifting chain, and on the larger the cage chain, passing up to the bottom of the counterweights. The drum winds itself along a screw thread cut in the fixed supporting shaft, the pitch of the screw being equal to the pitch of the lifting chain wound on the drum. The lead of the chain is thus kept fair.

It will thus be seen that in properly constructed hydraulic chain lifts there is practically no element of danger beyond that incurred by the use of the chain or rope; and that on the score of safety, even in chain lifts, hydraulic power is to be preferred to any other.

Any of the chain lifts which have been considered may obviously be adapted for passenger use, without any modification of the mechanism in itself; but, in order to secure greater steadiness of working, and comfort to the users, the guides and working parts should be more carefully constructed. The controlling gear is arranged so as to prevent the too sudden starting and stopping of the lift; and the cage is furnished with seats, and is of a more or less ornamental character. Double chains and safety apparatus are often introduced; but even where hydraulic gear is used, and all is done that is possible to secure safety, there still remains, in lifts so constructed, the considerable risk attaching to the use of chains or ropes for hoisting the cage. It is accordingly imperative, if passenger lifts are to come into more extended use, that some safer means should be adopted.

(*To be continued.*)

DIVISION D OF THE ONTARIO & QUEBEC RAILWAY.

BY DONALDSON BOGART DOWLING.

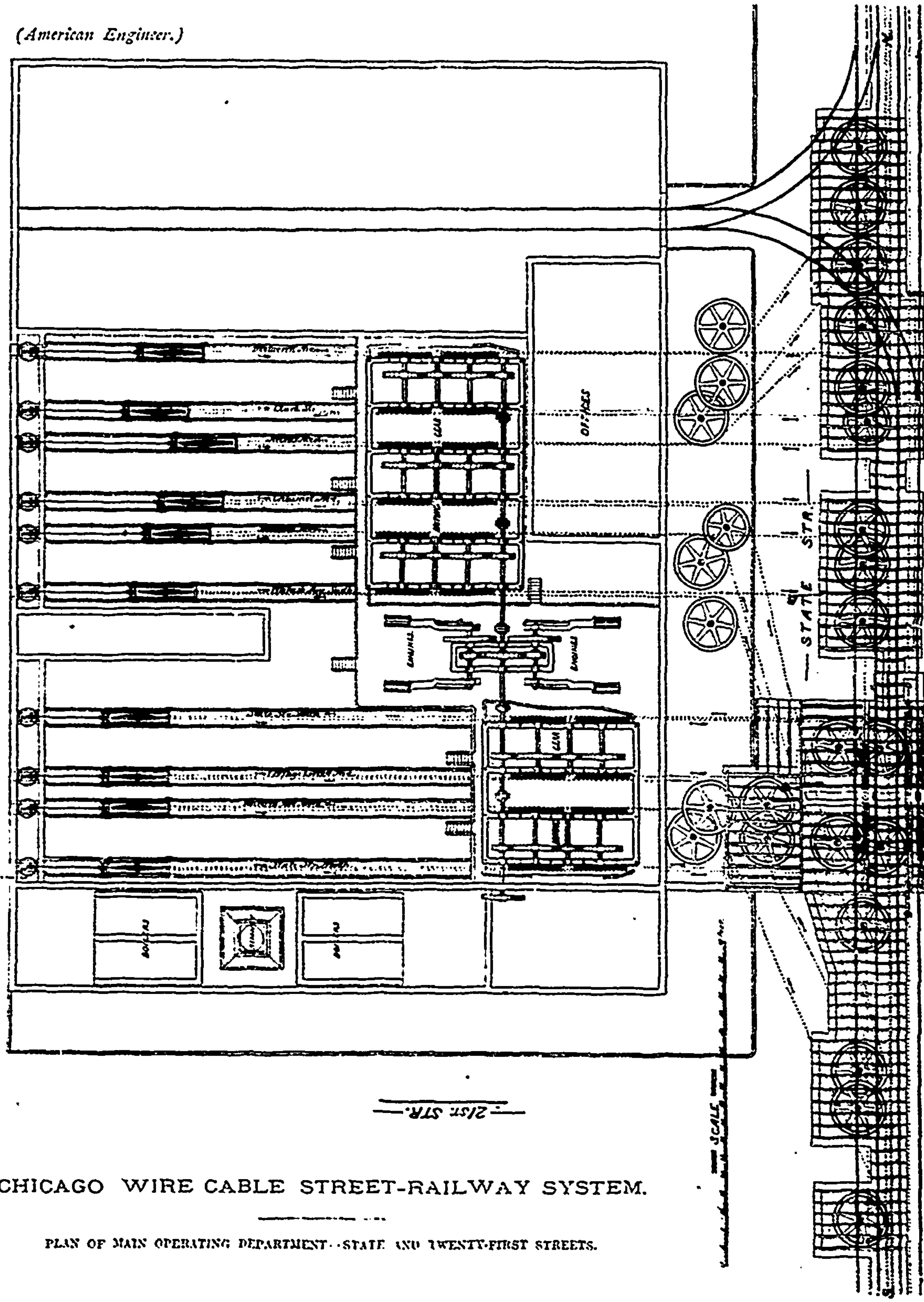
Division D of the Ontario and Quebec Railway, now in process of construction, lies about thirty miles north of the shore of Lake Ontario, in the counties of Hastings and Addington. The division is subdivided into seven sections, each five miles in length, and numbered from the west towards the east, beginning with 24 and ending with 31. Section 24 runs through a very well settled country, and, although the ground is rather hilly, the soil to be moved has not as yet been found to be very hard but contains a large number of boulders which render its manipulation rather more costly than was at first anticipated. The line in this section crosses, *on the level*, the Ontario Central which is now under construction and runs northward to newly discovered iron mines. Although the Ontario Central,—a continuation of the Prince Edward Railway—is merely a local line, a union station at the crossing would have been convenient, but has been found impracticable owing to the heavy grade which is something like ninety-three hundredths of a foot in one hundred (93 per 1,000). The only suitable site for a station is about one mile further east.

Continuing eastward from section 24 we find the nature of the country still hilly, but the line is so located that very few large cuttings are necessary and considerable cost is thereby saved as the soil here is not of a kind to be moved cheaply, being filled with a great number of boulders so large as occasionally to require blasting. The rock formation from section 24 to about section 29, is Trenton limestone which affords excellent material for the construction of stone drains and culverts at almost every point, obviating the necessity of a lengthy haulage. In section 26 the line crosses by an overhead bridge (a proposed design for which is shown on page 13) the Belleville and North Hastings Railway which runs along a narrow valley here bounded by banks more than twenty feet high (I). The bridge site is approached on both sides by cuttings, and the creek shown on page 16, is to be diverted. The chords of the bridge are composed of four timbers, those in the top chord having a scantling of 10 ins. by $6\frac{1}{2}$ ins. and those in the bottom chord of 12 ins. by $6\frac{1}{2}$ ins. The timbers are bolted together by $\frac{3}{4}$ in. bolts and are kept one inch apart by white oak keys, 3 ins. thick, let one inch into each member. The joints fail between two sets of keys and those in the lower chord are formed as shown on the drawing. The braces are double, that is, are composed of members between which the counter-braces pass. The braces vary in size with the distance from the centre, being 8-ins. x 10-ins., 8-in. x 9 ins., 8-ins. x 8-ins. and 8 ins. x 7-ins. in the first, second, third and fourth bays respectively.

The corresponding counter-braces are 7-ins. x 7-ins., 7-ins. x 8 ins., 7-ins. x 9-ins., and 7-ins. x 9-ins. The end verticals consists of two $1\frac{1}{4}$ ins. rods, the next set consists of three $1\frac{3}{8}$ in. rods, the third of three $1\frac{1}{2}$ in. rods, the fourth of three $1\frac{5}{8}$ in. rods, and the fifth of three $1\frac{1}{4}$ in. rods. The braces and counter-braces abut against cast iron angle blocks with surface ridges which are let into the braces and so prevent lateral displacement. The tie rods pass through the chords and angle blocks, and are secured at the top by nuts, the surface of the timber being protected, wherever necessary, by wrought iron washers. In order to provide for wind pressure, timber braces are introduced between the chords both at the top and bottom. These braces have a scantling of 6 ins. x 7-ins. and their ends are kept in place by the $1\frac{1}{4}$ in. tie rods, which are spaced about fifteen feet apart. Between the lower chords are placed the needle beams upon which are laid 10-ins. x 12 ins. track stringers to receive the cross ties and rails.

The clear width between the trusses is 14 ft. and the clear height above the rails is 17 ft., 6 in., allowing ample headway for the passage of trains. The abutments are being built according to the designs shown on page 16. The excavations are carried down to

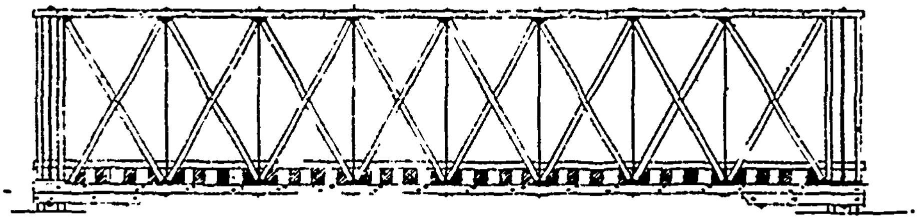
(*American Engineer.*)



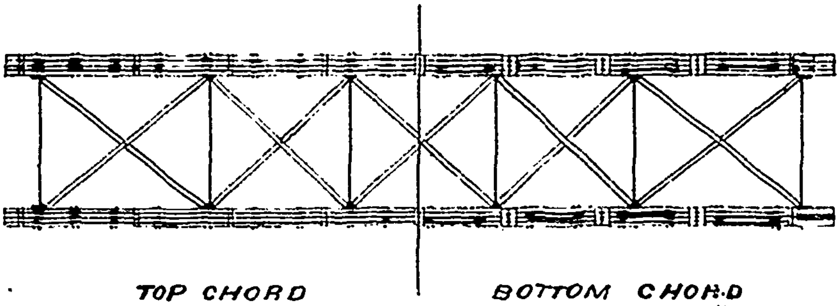
CHICAGO WIRE CABLE STREET-RAILWAY SYSTEM.

PLAN OF MAIN OPERATING DEPARTMENT—STATE AND TWENTY-FIRST STREETS.

Howe Truss

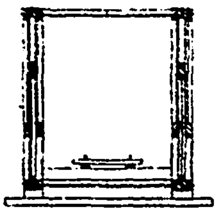


ELEVATION

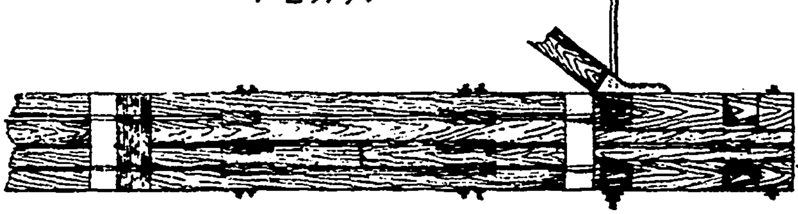


TOP CHORD BOTTOM CHORD

PLAN



SECTION



DETAIL OF BOTTOM CHORD

CROSSWAYING

the solid rock. In both abutments the batter given to the front is 1 in 12, to the rear of the wing walls 2⅞ in 12, to the ends 1 in 12, and to the rear of the centre portion 1⅞ in 12. These piers are to be built of first-class masonry, the quality of which must fulfil the following specification :—

"The stone shall be laid at the rate of one header to two stretchers disposed so as to make efficient bond. No stone to be less than twelve inches in thickness. None to have greater height than width and all to be placed on their natural bed. The masonry throughout to have hammer dressed beds and joints. Vertical joints to be continued back from the face of the wall at least ten inches. The mortar joints on the face not to exceed one-fourth of an inch in thickness. The stone must be dressed complete before laying, and not to be moved after being placed in the mortar. The face will not be tooled but only roughly dressed, except for one-half inch from the beds and joints where it will be hammered. Also the mortar to be used must be of the best cement and will be subject to the inspection of the Engineer in charge."

Proceeding eastward from Crookston the line passes through the village of Tweed and is to be carried over the Moira river by an iron bridge of two spans, each one hundred feet in length. At this village is located the factory for the manufacture of the explosives to be used in the rock work lying to the east. The rocks here still belong to the Trenton formation, but from about the middle of section 29 eastward, for twenty or thirty miles the formation is wholly Laurentian. The country too, in these sections, 29, 30 and 31, is very rough and there will necessarily be many heavy rock cuttings so that the construction of the line will be both difficult and costly. The work may be lightened to some extent by raising the grades. For this purpose embankments are to be made which will not only consume all the available earth, which for some distance is rather scarce, but also large quantities of rock which will have to be *bored*. Between many of the hills occur long stretches of marsh land, which in summer is moderately dry and covered with a growth of long stout grass, but in the fall and early spring are transferred into small lakes, so that the whole surface of the marsh instead of being solid is sponge-like and impassable for some time after the water has disappeared.

In these places it is difficult to obtain a good firm road bed and this has only been accomplished by *crossways* (page 13). The timber in this district has in great measure been left standing, and excepting where the trees have been destroyed by fire, or where the large pine has been cut down by lumbermen, the land is in its primeval state and sufficient timber can generally be obtained for this purpose. The logs when laid across the road bed must have their ends at least two feet within the line of slope stakes so as to ensure their being wholly covered with earth when the bank is built. Above the logs brush is to be laid to a depth not exceeding one foot. Very few of the swamps require to be treated in this manner as the depth of the soil in many of them is only sufficient to hold the roots of small trees and is often less than 12 in. Hence, by digging a drain on either side of the road the water may be quickly drained off. As already remarked, many heavy rock cuttings will occur in the last three sections in the Division and steam drills are being introduced by which the work will be done more quickly and with less expense. A preliminary and important difficulty is the cartage of these heavy machines to the proper sites, as they have to be hauled over many exceedingly rough stretches of country.

Very few houses are to be met with in this part of the county and indeed in travelling along the ten miles of the railway, in sections 30 and 31, there is only one, a stopping place on the Addington Colonization Road generally known as "Scoutens."

The work of building a road in this district is thus necessarily prefaced by that of building dwellings. Camps are generally erected for the men who are working on the road, but many of them prefer to live at the nearest farms.

In laying down a road in a country similar to that described above, the line must be thoroughly cleared between the right of way stakes, and this includes the operations of chopping, logging, and burning. All objectionable trees on adjoining lands, which are liable to fall across the track or fence, must also be cut down The Engineers have then to lay out the work and cross-section the ground. After this the earth is moved. If rock is met with in a cutting, the earth is cleared off from its surface and new cross-sections are made so as to determine accurately the relative quantities of earth and rock.

The culverts along the line are to be made of stone and are sufficiently explained by the drawings, (page 17) except when a culvert is built of dry stone masonry, in which case the ends are to be stepped and the outside dimensions increased one-fifth.

Where larger openings are required, beam culverts are built—a type of which is shewn on page 17.

N. B.—Abstract of Prize Summer Report for 188[illegible], in the Faculty of Applied Science, McGill University.

THE PATENT PLUMBAGO CRUCIBLE COMPANY BATTERSEA.

Among the recent donations to the Faculty of Applied Science in McGill University may be noticed an interesting series of articles manufactured by the "Patent Plumbago Crucible Company," of Battersea, England, and presented through Mr. J. V. Morgan, of Montreal. The works of the company were started more than a quarter of a century ago, and have been gradually extended to meet the requirements of the various trades which they supply, until they have become the most extensive crucible works in existence. Their "Morgan crucible" is said to be exclusively used in the Royal Mint, and is favourably known in every large foundry throughout the world. The "Salamander" is another crucible which is well known and is specially prepared to resist dampness, and thus to reduce to a minimum the difficulty and risks of annealing." Specimens of the "Morgan" and "Salamander" are to be seen in the collection presented to McGill College, as well as crucibles of several other patterns, scorifiers, roasting-dishes, muffles, fire-clay retorts, porous battery cells, etc., etc. There are also samples of the crude plumbago imported by the Company from Ceylon, and of the prepared article for dusting moulds in foundries, for glazing gunpowder and shot, etc.

The whole series is arranged in the museum of the Science School, where it forms a part of the technical collection now being brought together by the Faculty.

B. J. Harrington, Ph. D.

EFFECT OF PRESSURE UPON THE COERCITIVE FORCE AND MALLEABILITY OF STEEL.

In March 1882, M. Clémandot communicated an article respecting the properties acquired by steel subjected to great pressure and cooled under such pressure. Among the properties, having a complete analogy to those given by the bath tempering process, is coercitive force, that property by means of which steel can acquire and retain magnetism.

M. Clémandot continued his investigations and he recently published new and interesting results.

He says, "the ordinary process of tempering consists in heating the steel to a cherry red and in suddenly cooling it by plunging it into a bath of water, oil, or any other liquid, the metal is then hardened, tempered, it has acquired coercitive force. What happens if the steel is again heated? It becomes soft, its coercitive force disappears. But what happens when the steel is tempered by compression, i.e., cooled under pressure after the sudden cooling partly obtained by compression? The coercitive force will be found to have been retained in spite of reheating, in spite even of forging. In other words, instead of being ephemeral, as is the coercitive property due to the temper obtained by the bath process, that given to the steel by compression will be permanent, to whatever operations it may be subsequently subjected. This result must be attributed to the more absolute homogeneousness caused by the compression and by the cooling under pressure.

The result is interesting both from a scientific and metallurgical point of view.

In support of the above theory M. Clémandot states the following facts — "Several plates from a magneto-electric pile were broken and forged into a bar, the bar was compressed, the plates were re-constructed, and were found to possess the same magnetising force (1?) by the galvanometer as those which were broken up. Similar experiments were made upon a large number of telephones, the magnetic force was not only preserved, but was increased by the different modes of treatment to which the steel was subjected.

Under these circumstances compression and cooling under pressure constitute a new metallurgical process. Great practical advantages ensue from treating the metal in this manner; for while steel tempered by baths is hard, intractable, and often distorted, steel subjected to pressure and then re-worked is malleable; it may be filed, punched, &c. This fact is of much importance to manufacturers of magnetic apparatus, magneto electric machines, telephones, &c., as valuable time is often lost in working upon magnets which may break in pieces at the last moment.

A Note by M. M. de la Tour du Breuil concerning their method of separating Sulphur from its gangue by means of a Bath at a higher temperature than the fusing point of Sulphur.

The arrangement of the apparatus has become a matter of importance in consequence of the investigations which have been necessary with respect to minerals of a special kind from the islands of Milos and Nisyros. The immersions of the ore in cages or baskets has become impracticable; the fusion of the sulphur was always slow and incomplete. We have been compelled to adopt an arrangement consisting in the employment of two rectangular tubs, communicating with each other by a tube which allows of the passage of the boiling bath alternately from one tub to the other, one of the tubs is emptied and refilled while the other is working. The orifice of flow is composed of a tube widened towards the outside, warmed by the flame and closed on the inside by a stopper worked by a screw.

The ores of Milos and Nisyros are composed of sands agglomerated by sulphur. When the fusion of the sulphur takes place, the mineral is separated, and the sand is drawn away by the fluid stream; to avoid this inconvenience, a central trench has been arranged at the bottom of the tubs which serves as a collector, and which has an inclination only sufficient to cause the flow of the sulphur towards the efflux orifice. Two vertical gratings ensure the separation of the sulphur from its gangue.

The apparatus thus modified may be used indifferently with intractable ores, and ores in a state of powder. It has been successfully applied to the treatment of the *sterri* of Sicily, i.e., the powdered and very rich debris produced during the work ing and manipulation of the ore.

These *sterri*, hitherto disregarded on account of the impossibility of their treatment by the *calcaroni*, are at present found in considerable quantities. The employment of new apparatus, already at work for several months in Sicily, has rendered it possible to obtain an amount of 30 to 60 per cent. in merchantable sulphur, i.e., an amount much greater than that obtained from the richer ores treated by the methods of the calcaroni or others.

ENGINEERING NOTES.

The Northern Pacific Bridge.—The new bridge of the Northern Pacific Railroad, which crosses the Missouri River at Bismark, D. T., was tested and formally opened to traffic on Oct. 21. Eight locomotives, aggregating 500 tons, passed over the bridge and rested on each of the 500-foot spans, while the engineers took observations. The deflection of each span was less than three inches. The testing committee, composed of eminent civil engineers from various parts of the country, pronounced the structure one of the finest and most complete in the West.

The dimensions of the Union arch of the Washington aqueduct, it would appear, exceed those of any of the celebrated engineering structures which are most commonly pointed to as wonderful achievements in masonry. The entire span is 220 feet or twenty in excess of the span of the famous Chester arch across the Dee in England; 68 feet longer than the central arch of London Bridge; 92 feet longer than the noted bridge over the Seine at Neuilly, and 100 feet longer than the arches of the Waterloo Bridge over the Thames. The height of the Washington arch is 101 feet.—*Scientific American.*

At a meeting of the Philadelphia Society of Engineers the Secretary presented, for Mr. Howard Constable, a description of the Kinzua Viaduct, the *highest bridge structure* in the world, illustrated by numerous general and detail drawings and photographs. It forms part of a branch of the Erie Railway into the coal fields of Elk County, Pa., and its construction was found to be the most economical way of crossing the Kinzua Gorge, a long time obstacle in the way of railroad construction. Surveys and investigations leading to the conception of this work, were made by Mr. O. W. Barnes, chief engineer of the road, before it passed into the hands of the Erie Railway. It was built according to Erie specifications, by Messrs. Clarke, Reeves & Co., under Mr. O. Chanute, chief engineer, assisted by Messrs. Chas. Pugsley, H. C. Keifer, and the author. It contains 3,500,000 pounds of iron and cost $275,000. The paper describes the work very completely and concludes with the following table of data:

DATA.

Total length of viaduct	2052 ft.
Height of rail above stream	301 ft.
Number of towers	20.
Height of iron work of lowest towers	16 ft.
Height of iron work of highest towers	278' 3"
Length of girders over towers	38½ ft.
Length of girders between towers	61 ft.
Width of towers at top	10 ft.
Width of towers at bottom	10 ft. x ¼ of height.

Live Load "Consolidation" Engines in any Position.

	Pounds.
Equal on each column of tower at top	76,500
Dead load on top of each column	22,950
Dead load on each story per column about.	5,000

Girders, Calculated for a Train of "Consolidation" Engines.

	Pounds.
Chords strained in tension per square inch of net section	8,000
Chords strained in compression per square inch of gross section	7,000

Diagonals strained per square inch from 5,000 to 7,000.
Rivets strained per square inch, 5,000.

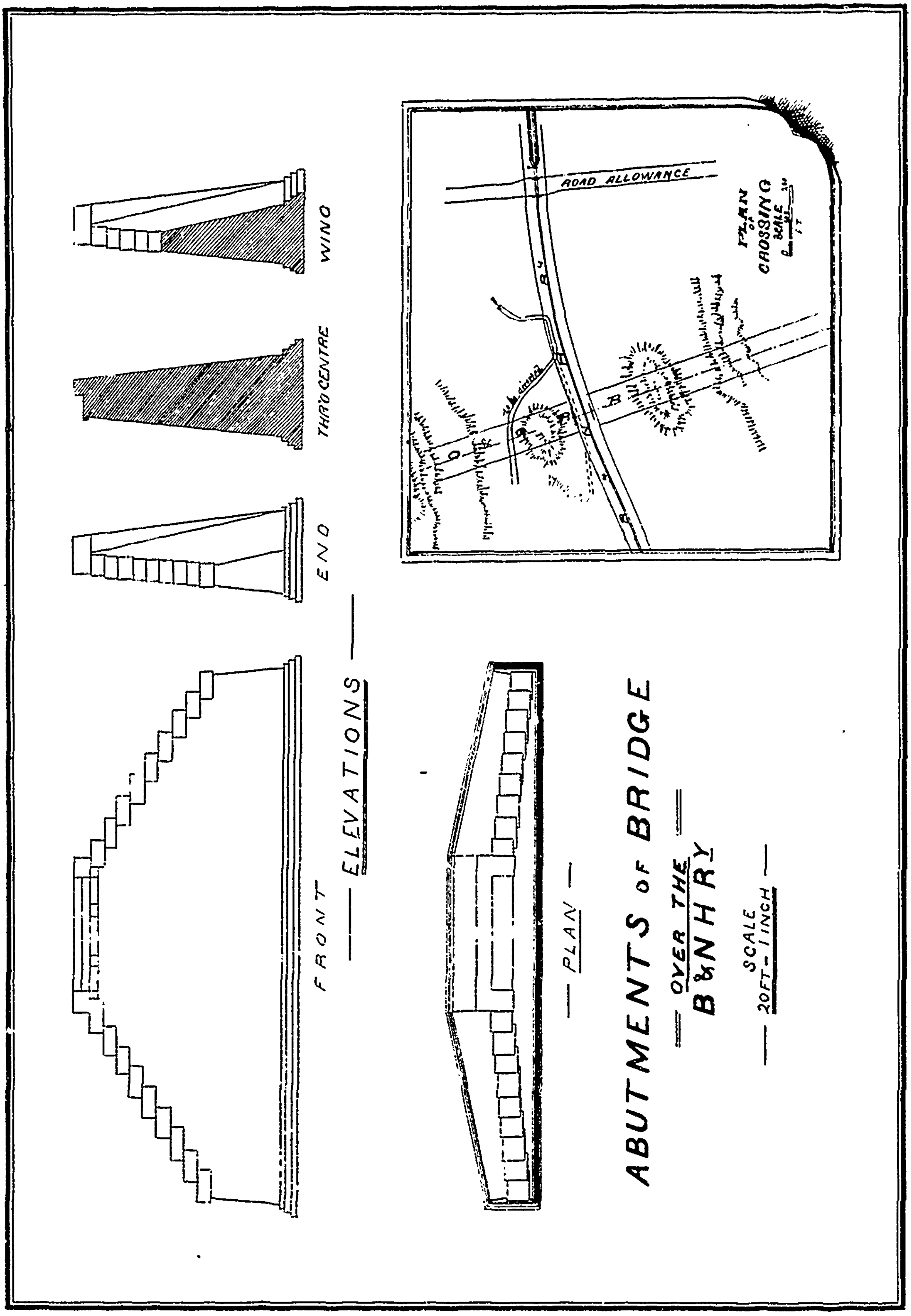
WIND PRESSURE.

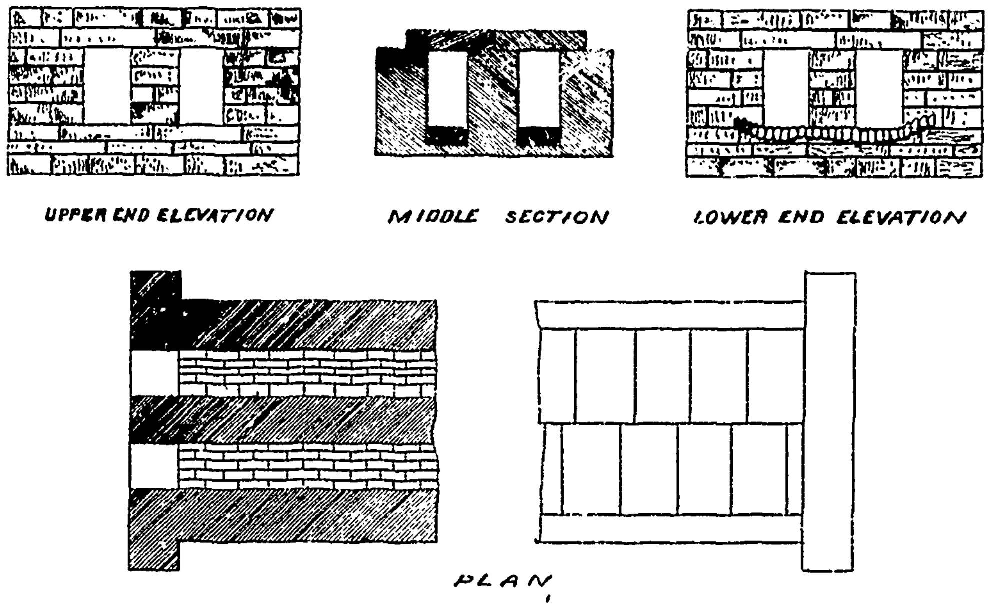
Maximum Compression. Structure Loaded.

	Pounds.
Pressure assumed at the top of each bent	20,000
Additional pressure at each story of tower.	1,980

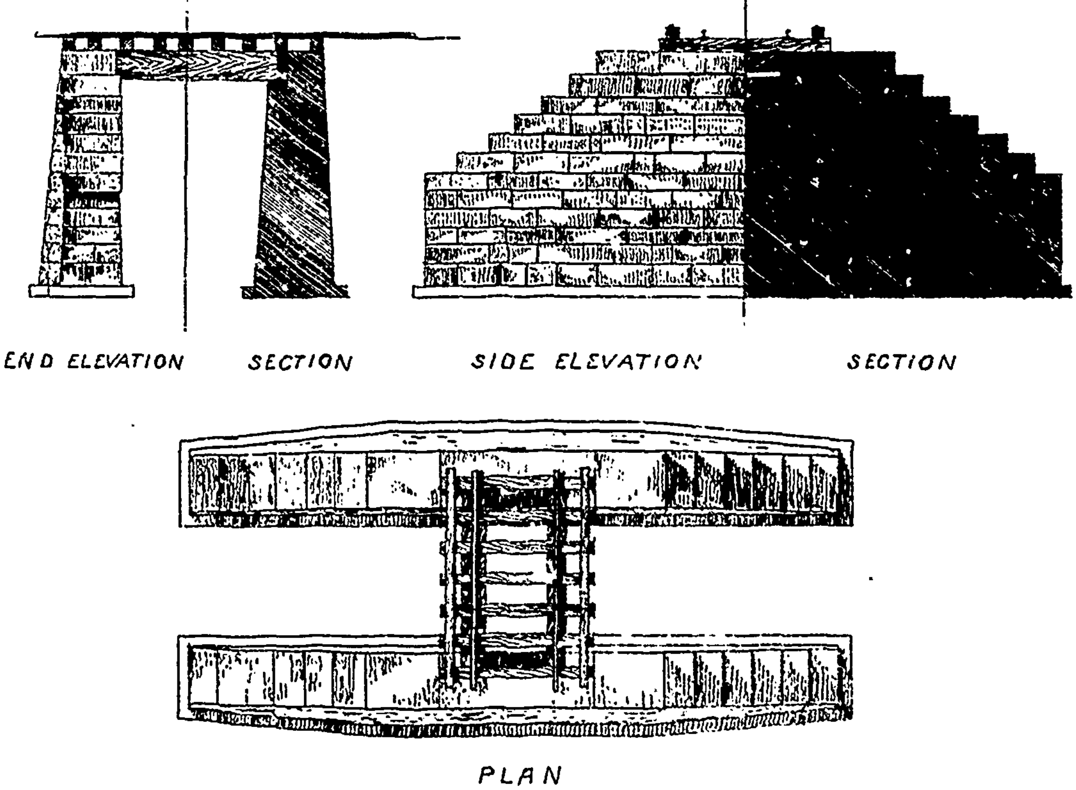
Maximum Tension. Structure unloaded.

	Pounds.
Pressure assumed at top of each bent	15,000
Additional pressure at each story of tower	3,200
Strains allowed on "Phœnix" columns, of the length used, (16 to 33 ft.) with an ultimate strength per square inch of	35,000
Maximum compression from live load per square inch	7,000
Maximum compression from wind pressure per square inch.	10,000
Greatest strain for combined loads	8,000
Maximum tension on diagonals (rods)	15,000
Maximum strains on struts	2 to 3,000
Maximum tension on anchor bolts	12,000


ABUTMENTS OF BRIDGE
OVER THE
B & N H RY
SCALE
20 FT = 1 INCH
FRONT
ELEVATIONS
END
THRO' CENTRE
WING
PLAN
PLAN OF CROSSING
SCALE
ROAD ALLOWANCE



STONE CULVERT



BEAM CULVERT

THE largest suspension bridge will be the one now building between Brooklyn and New York. The length of the main span is 1,595 ft. 6 in. The entire length of the bridge is 5,989 ft.

THE Pennsylvania Railroad's new locomotive *Jumbo* has seven-feet driving wheels, and has drawn a train from Philadelphia to Jersey City, a distance of ninety miles in eighty minutes.

THE longest span of wire is used for a telegraph in India over the river Kistnah, between Bezorah and Seetanagrum. It is more than 6,000 ft. long, and is stretched between two hills, each 1,200 ft. high.

AN English patent provides for using two sets of driving-wheels on one axle of locomotives, one set being larger than the other. On levels the large wheels run on the rails, but on inclines an extra set of rails are provided upon which the small wheels run while the large wheels revolve in the air.

THE *American Machinist* says "Crude petroleum put into steam boilers will loosen and precipitate the scale, but will not remove it outside of the boiler and fire-room. These facts do not seem to be fully realized until the boiler is burned or otherwise injured by excessive heat upon plates with which the water cannot come in contact. Boilers should in all cases be frequently and carefully washed when using substances for the prevention of scale."

STEAM ROAD CARRIAGES.—The principal cause of the lack of success in building a practical steam road carriage is the difficulty experienced in the efforts to so "hang" the engine and boiler that the carriage may run in any direction, or over ordinary obstacles, without seriously affecting the joint and machinery connections. So says an eminent mechanical writer. Even the English acknowledge this in their efforts to run steam road carriages over the exceptionally good roads of England.

PROFS. WELLNER and Brun, of Austria, have recently patented a new steam engine which consists of a simple water wheel, mostly immersed in hot water in a closed vessel. Steam is admitted at the lower part, and forces the cells on the rising side, and at length begins to escape into the steam space above the water. Steam may either be produced directly at the lower part, or conducted to the vessel from elsewhere. The upper tube for outlet of steam may lead either into the open air or into a condenser. The mechanical work consists in the ascent of the specifically lighter stream in the heavier liquid.

An improved feed-water heater and purifier has been recently described to the Franklin Institute by Mr. George Strong. It is said to effect a saving in coal of 22 per cent., and an increase of evaporation of 1·09 pounds of water per pound of coal. Considering that all substances likely to give trouble by deposition would be precipitated at about 250° F., he obtains this in the heater by action of exhaust steam, aided by a coil of live steam from the boiler. He also uses a filter formed of wood charcoal, and bone-black firmly held between two perforated plates. Further details will be found in the *Journal* of the Institute for November.

IN an article by T. Bruce Warren in the *Journal of the Society of Arts*, the statement is made that very often the grease which passes into a steam boiler in the feed water does not make its appearance in the scale or mud which is thrown upon the bottom plates. He found out, however, by analysis, that the floating scum from the boiler did contain a notable percentage of the fatty acids. He attributes the fact that none of the gases were detected in the bottom scale to the decomposition of the falling acids by the heat to which they were subjected, and the preservation of the grease at the surface to the fact that it had taken the form of an insoluble earthy soap, light enough to float.

A locomotive boiler, it is calculated, will last until the engines has travelled over 350,000 miles. On some lines, however, the boilers, under favorable circumstances, particularly when pure water is used, may travel 400,000 or 500,000 miles before becoming unserviceable. Assuming that the life of the engine is determined by the endurance of the boiler, and that, under favourable circumstances, it will last the 500,000 then during that time it is estimated that the fire box will probably require to be renewed at least three times, tires of the wheels five or perhaps six times, the crank axles three or four times, and the tubes from seven to ten times.

CARE AND USE OF BELTS.—In lacing a belt, always begin at the centre, keep the ends exactly in line, and lace both sides with equal tightness. The lacing should never be crossed on the side of the belt that runs next the pulley. Use thin but strong laces. Belts should never be oiled except when they become hard and dry, and even then the oil should be used very sparingly. Oil not only rots the leather, by its own decomposition, but also causes the belt to stretch. In oiling or greasing a belt use only a pure thin oil. A thick pasty oil is not good. Such oil will soon enter upon a process of decomposition and rot the belt.

Experiments made by Mr. F. E. Kidder, and reported in the last issue of the *Journal* of the Franklin Institute, show that spruce beams loaded to one-half to two-thirds their breaking strain, finally break after a long and steady deflection, which continually increases until the final rupture occurs. If substantiated by further experiments, this fact will go far toward explaining the frequent falling of mill and warehouse floors, under loads supposed by the builders to be perfectly safe. The floors of all such buildings should be sufficiently strong to carry at least three times the weight that can, by any possibility, be put on them, and at least five times as strong as the ordinary load. Where there is running machinery in the building which is likely to produce jar or tremble, these figures must be exceeded, as the effect of continuous jar and strain combined is very destructive to the building in which they are found.—*Wood and Iron.*

It is estimated that the annual production of iron throughout the whole world is 19½ millions of tons. This amount is distributed among the various nations as follows:—

Nations	Years	Number of Tons
England	1881	8,377,361
United States	1881	4,144,254
Germany	1881	2,863,400
France	1881	1,866,438
Belgium	1881	622,288
Austria and Hungary	1880	448,685
Sweden	1880	399,628
Luxembourg	1881	259,212
Russia	1881	231,311
Italy	1876	76,000
Spain	1873	73,000
Turkey	—	40,000
Japan	1877	10,000
Other Countries	—	46,000
		19,487,610

The first four nations produce 88 per cent. of the total output. The United States consumes the most (29 per cent.), Great Britain consumes 23 per cent. These two nations use more than one-half of the total production.

According to a recent treatise on the transmission of power by wire ropes, issued by the William Orton Manufacturing Company, of Sterling, Ill., the distance to which wire rope transmissions may be applied ranges from 50 or 60 feet up to several miles. As an example of long transmission, attention is directed to that of Schaffhausen, Switzerland, at the Falls of the Rhine. Here 500 horse-power is carried diagonally across the line, is extended for a distance of two miles, and is then distributed among 50 different manufactories situated in every imaginable position, and embracing all the varied arrangements of changing directions. Wire rope transmission comes into use at the point where a belt or line of shafting becomes too long to be used profitably. In point of economy it is much cheaper than its equivalent, either in shafting or belting. This method has been extensively introduced in Europe, and with great success, for several years past. It is now receiving a rapid development in this country. It has the advantage of transmitting power in any direction, up or down hill, across rivers, around buildings or obstructions of any kind, and of thus making available many sources of power which are otherwise useless. The ropes hang free in air, and require no protection from the weather, except an occasional coat of warm coal tar, which may be applied to the rope by pouring from a can into grooves of the wheel while running. Instead of coal tar, raw linseed oil may be swabbed on the rope to keep it from rusting, and thereby preserve it. The ropes run with perfect smoothness and without noise on vulcanized rubber filling, and are not affected in the least by wet or cold, snow or ice.—*Scientific Press.*

PRACTICAL EFFECT OF COLD ON IRON.—Careful observations on Russian Railways have resulted in showing that for a period of six months 77 per cent. of the fractures of tires occurred when the temperature was below zero, and only 19 per cent. at higher temperatures.—*Scientific Press.*

PNEUMATIC TUBE FOR PHILADELPHIA.—The Post Office Department is considering the feasibility of putting in very large pneumatic tubes for the Philadelphia Post Office, connecting it with the mail depots in the city. The object is to avoid the slow transference of mails from trains by coaches to the central office. No steps as yet have been taken in regard to actually putting the plan in operation.—*Mining and Scientific Press.*

CHINESE STEEL.—A considerable steel-making industry exists in China, on the upper Yangtze, whence the steel is sent to Tientsin for shipment and distribution. It realizes much higher prices than the Swedish steel imported into the country. The Chinese metallurgists recognize three kinds of steel, viz, that which is produced by adding unwrought to wrought iron while the mass is subject to the action of fire, pure iron many times subjected to fire, and native steel, which is produced in southwestern China.

MICA MASKS.—In Breslau mica masks are manufactured, they are very useful for workmen exposed to high temperatures, acid vapours, sparks or to metal or stone splinters.

The mica plates are fixed in metallic bearings protected by amianthus (or asbestos.) The masks protect the eyes much better than spectacles. The neck and shoulders may also be shielded by a covering made of amianthus, or other similar substance. The space between the mask and face allows of the use of spectacles.

UTILIZING THE EARTH'S HEAT.—We were not aware that our suggestion to the Californians to utilize heat drawn directly from the earth, was already carried out in Nevada, by means of the hot water obtained from the famous Sutro Tunnel. This enormous bore, now completed, discharges 3,000,000 gallons of hot water daily from the Comstock mines. This water has a temperature of 195 degrees, and is conveyed through a closed pine flume to prevent the escape of vapour. After a passage of four miles through the first tunnel it loses seventy degrees of heat. A second tunnel 1,100 feet long and an open waterway a mile and a half long conduct the water to Carson River. Along its course are hot water baths and laundries, and a plan is on foot to conduct the hot water through pipes under ground to be made available for purposes of irrigation and for supplying artificial heat to hot houses.—*Industrial News.*

The extensive use to which nails and screws are put in construction lends considerable interest to any records of experience tending to discover their holding power. Haupt, in his "Military Bridges," gives a table of the holding power of wrought-iron rod nails, 77 to the pound, and about three inches long. The nails were driven through a one-inch board into a block and the board was then dragged in a direction perpendicular to the length of the nails. Taking a pine plank nailed to a pine block with eight nails to the square foot, the average breaking weight per nail was found to be 380 lbs. Similar experiments with oak showed the breaking weight to be 415 lbs. With 12 nails to the foot square the holding power was 512½ pounds, and with six nails in pine, 463½ pounds. The highest result obtained was for 12 nails to the square foot in pine, the breaking weight being in this case 612 pounds per nail. The average strength decreases with the increase of surface. Tredgold gives the force in pounds required to extract 3d. brads from dry Christiana deal at right angles to the grain of the wood as 58 pounds. The force required to draw a wrought-iron 6d. nail was 187 pounds, the length forced into the wood being one inch. The relative adhesion when driven transversely and longitudinally is, in deal, about two to one. To extract a common 6d. nail from a depth of one inch in dry beech, across grain, required 167 pounds, in dry Christiana deal, across grain 187 pounds, and with grain 87 pounds. In elm the force required was 327 pounds across grain, and 257 with grain. In oak the figure given was 507 pounds across grain. From further experiments it would appear that the holding power of spike-nails in fir is from 460 to 730 pounds per inch in length, while the adhesive power of screws two inches long, 22 inch in diameter at the exterior of the threads 12 to the inch, driven into ½ inch board, was 790 pounds in hard wood and about one-half of that amount in soft wood.—*Mining and Scientific Press.*

ELECTRIC TRANSMISSION OF POWER.

IN *La Lumière Electrique* M. Guerout cites two samples of the transmission of power to a moderate distance. At the Belle Jardinière sewing machines on the upper flats of a building were worked by power transmitted from a motor in the basement. In Heilmann, Ducommun, and Steinlen's Exhibit at the Palais de l'Industrie, the generators in one division were arranged in two rows and worked from a steam motor, in the other division, a workshop of machine tools was kept in operation by two gramme machines (type A). Three H.P., sufficient to work ten tools, were transmitted through the connecting wires. A part of the current produced by the generators fed Werderman-Reynier and Edison lamps to light the shop.

Hitherto very little has been done in the electric transmission of power to great distances. At the request of the Munich Electrical Exhibition Committee, M. Deprez repeated on an ordinary telegraph line certain experiments he had previously made on the transmission of force. The description of these experiments is thus given in the *Comptes Rendus*, October, 1882:—The telegraph line placed at his disposal was 57 kilometres (187,009 ft.) in length. The conducting wire was of galvanized iron 4½-millimetres (.17-in) in diameter. A return wire of the same size was used in preference to the earth. The total length of circuit was therefore 114 kilometres and the measured resistance 950 ohms. The insulation was good but did not differ from that in general use on telegraph lines. The two electrical machines, wound with fine wire, one at Miesbach and the other at Munich, were absolutely identical, the resistance of each being 470 ohms. The total resistance of the circuit was therefore 1,890 ohms. In the first experiment the Munich machine, making 1,500 revolutions per minute, gave ¼-horse power. The generating machine at Wiesbach made 2,200 revolutions per minute. The two machines being identical, the ratio of work received at Munich to the work expended at Wiesbach was 1500-2200, or more than 68 per cent.

A heavy rain fell nearly the whole time occupied by the experiments.

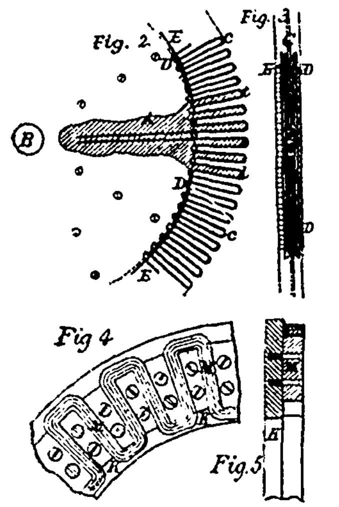
The receiver actually served to feed a cascade 1 meter (3.28 ft.) in width and 3 meters in height, by means of a centrifugal pump. The collectors of the machines gave sparks which were scarcely visible, while the heating of the machines was hardly appreciable after two hours work.

RECENT DYNAMO-ELECTRIC MACHINES.

ELECTRICAL inventions of innumerable kinds have of late followed one another with bewildering rapidity; and the impetus to invention afforded by the present development of electric lighting, and by recent electrical exhibitions, is making itself felt in many ways. Most important, perhaps, of these is the production of improved types of machines for generating electric currents. Dynamo-electric machines, in fact, appear to be undergoing the same kind of evolution which the steam-engine has undergone; and just at present the tendency appeared to be in the direction of producing larger and heavier machines than heretofore.

The readers of *Nature* will be familiar with the description of Edison's large steam-dynamo, which first made its appearance in Paris in 1881, and of which two examples are now at work in the Edison installation at Holborn Viaduct. These monster dynamos, each requiring from 120 to 150 horse-power to drive it are capable of lighting from 1,000 to 1,300 incandescent electric lamps.

Six such machines have been also erected in New York to supply the central station of the Edison Light Company. Here the unexpected difficulty has arisen that if one of the machines drops in speed the currents from the other machines short-circuit themselves through the one, and overpower the steam that is driving it; a fault which will probably be remedied by a rearrangement of the governors supplying the steam to the engines. New forms of dynamo-electric machines have been designed by Sir William Thompson, some of these being for direct currents, others for alternate, but all of them of peculiar construction. The first of them, shewn in Fig. 1, may be described as a modification of Siemens' well known machine, the drum armature being, however, made up like a hollow barrel, of which B B is a sectional view, the separate staves being copper conductors insulated from one another. They resemble the longitudinal bars used by Siemens in the armatures of his electro plating machines, and by Edison in his steam-dynamo. At one end of the hollow drum these copper bars are united to each other in pairs, each to the one opposite it. At the other end their prolongations serve as commutator bars. A similar mode of connecting to that adopted by Edison, is also possible.



FIGS. 2-5.—Sir W. Thomson's Disk-Dynamo

Inside this hollow drum armature is an internal stationary electro-magnet, KM′K, whose poles face those of the external field magnets. This internal magnet answers the purpose of intensifying the magnetic field, and making

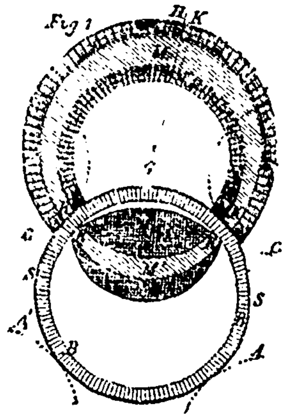


FIG. 1.—Sir W. Thomson's Roller Dynamo.

the magnetic system a "closed" one, as suggested long before by Lord Elphinstone and Mr. Vincent. This hollow armature Sir W. Thomson proposes to support on external antifriction rollers A A′ C C′, the lower pair A A being of non-conducting material, the upper pair being made up of conical cups of copper split radially, and serving, instead of the usual commutator "brushes" to lead away the current. The hollow armature may be driven either by the tangential force of one of the bearing rollers, or by an axle fixed into the closed end of it.

Another machine devised by Sir W. Thomson, and illus-

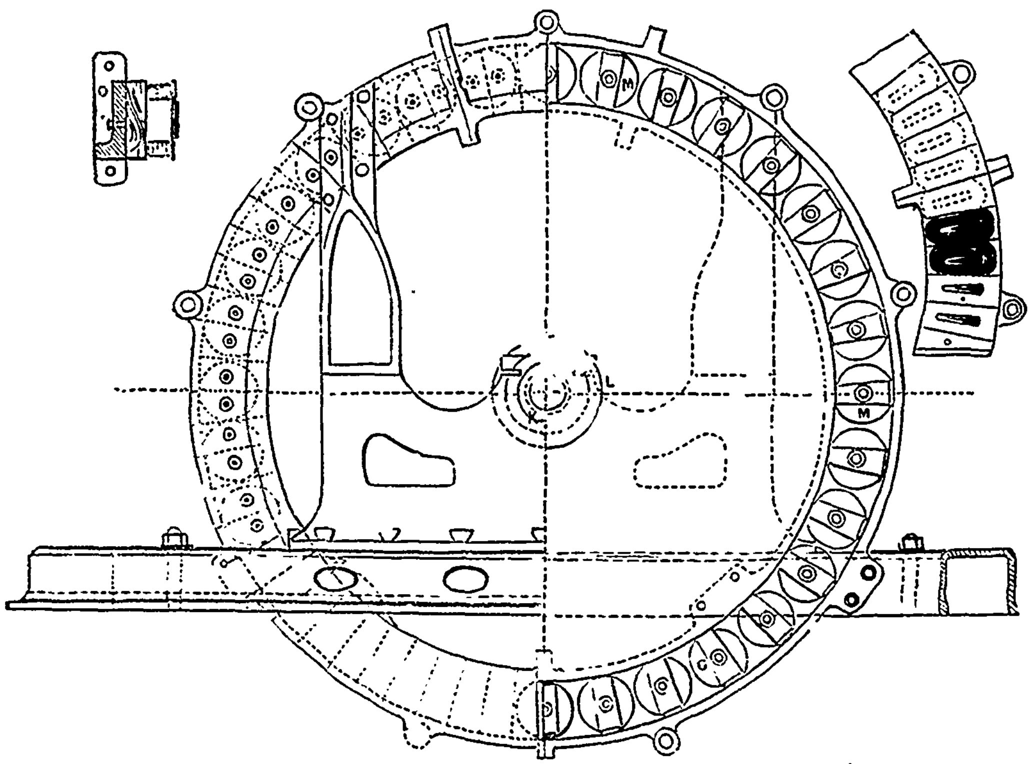


FIG. 6.—Elevation of Gordon's Dynamo, showing the rotating coils. The "taking-off" coils are shown in the top right hand corner.

trated in Figs. 2, 3, 4, and 5, is a disk-dynamo for generating alternate currents, and is therefore allied in certain aspects to Mr. Gordon's machine, described below. The rotating armature has no iron in it; it consists of a disk of wood having upon its sides projecting wooden teeth, as shown in Figs 2 and 3, between which a wire or strip of copper is bent backwards and forwards, and finally carried to the axle B. This disk is rotated between field-magnets having poles set alternately all round a circular frame. Figs. 4 and 5 show how this is carried out. A cast-iron ring having projecting iron pieces screwed into it is surrounded by zig-zag conductors which carry into it the current from a separate exciter. These currents pass up and down between the projecting cheeks, and excite those on both sides of them.

A still more recent, and still larger generator, is that designed by Mr. J. E. H. Gordon, whose "Physical Treatise on Electricity and Magnetism" is known to most of our readers. This machine, which is given in elevation in Fig. 6, and in end-elevation in Fig. 7, is more than 9 feet in height, and weighs 18 tons. It possesses several points of interest. The rotating armature differs from those of the well-known Gramme or Siemens' armatures, being in form a *disc*, constructed of boiler-plate, upon which the coils are carried. The machine, therefore, resembles in some respects the Siemens' alternate-current machine, though there are notable points of difference, the most important

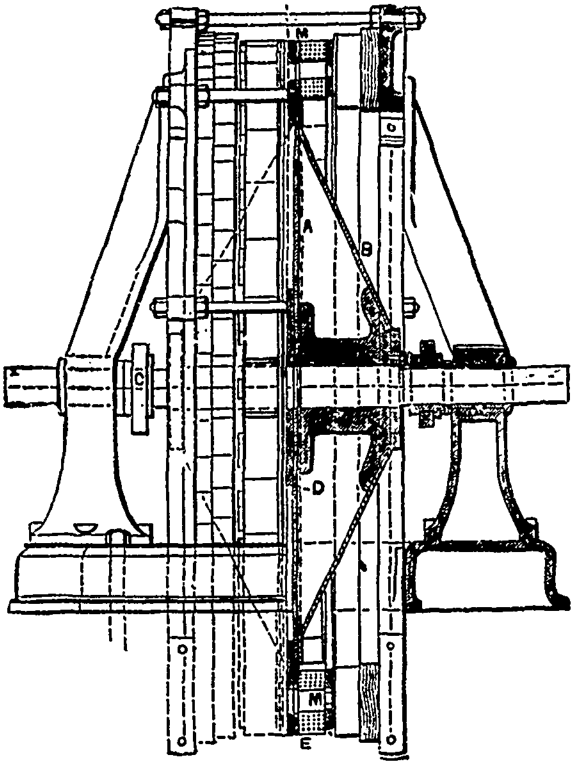


Fig. 7.—End Elevation and Section of Gordon's Dynamo.

being, that whereas in most dynamo-machines the inducing field-magnets are fixed, and the induced coils rotating, in Mr. Gordon's new machine the rotating coils are those which act inductively upon the fixed coils between which they revolve. The machine furnishes alternate currents, and therefore requires separate exciters. These exciters, two Bürgin machines, send currents which enter and leave the revolving armature by brushes pressing upon rings of phosphor bronze placed upon the axis at either side. There are 64 coils upon the rotating disc, and double that number upon the fixed framework. These 128 "taking-off" coils, the form of which is shown in Fig. 8, are alternately connected to two circuits, there being 32 groups in parallel arc, each parallel containing 4 coils in series; thus bringing the total electromotive force to 105 volts when the machine is driven at 140 revolutions per minute. At this speed it actuates 1300 Swan lamps, but is calculated to actuate from 5000 to 7000 if the driving power is proportionately increased. The machine is now in operation at the Telegraph Construction and Maintenance Company's Works, East Greenwich.

A great deal has been said in certain quarters of late about another new dynamo, the invention of Mr. Ferranti, which, with one of those unscientific exaggerations which cannot be too strongly condemned, was pronounced to have an efficiency five times as great as that of existing dynamos. The construction of this machine has not yet been made known, but it is understood that it has no iron in the rotating armature. This is, however, no novelty in dynamos. It appears, also, that Mr. Ferranti has invented an alternate-current machine almost identical with that of Sir William Thomson described above.

Lastly, M. Gravier claims to have designed a form of dynamo in which there are neither commutators nor separate exciters, but in which continuous currents of electricity are produced in stationary coils by the passage near them of a rotating series of iron bars whose mag-

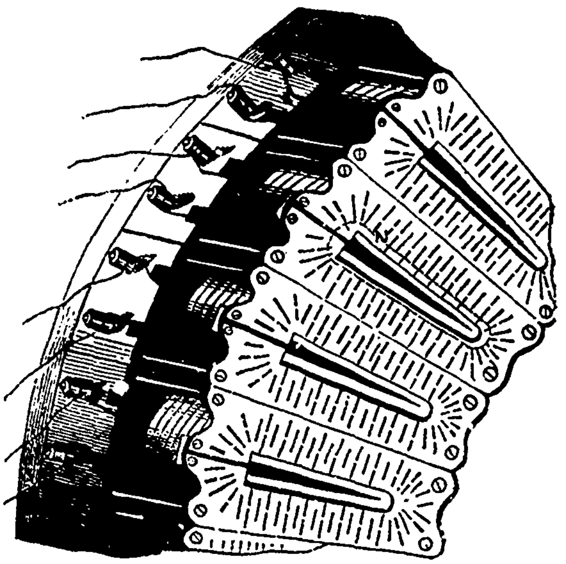


Fig. 8.—The Fixed Coils of Gordon's Dynamo.

netism is changed, during their passage, by the reaction of the cores of the stationary coils themselves. M. Gravier has also designed a machine in which a Gramme-ring is wound with two sets of coils, a primary and a secondary, each set having its own commutator on opposite ends of the axis. A current from a separate exciting machine passes into the primary coils of the ring by one pair of brushes, and the secondary current is taken off by a second pair of brushes at the other commutator placed at right angles to the first pair. We are not aware that any practical machine thus constructed has yet been shown in action.

It is certain that there is yet abundant room for great improvement in the construction of dynamo electric machines. But the inducements to improvement at the present time are so great that rapid progress toward the desired goal of perfect efficiency and simplicity of structure is more than assured.

EFFICIENCY OF LIGHTNING CONDUCTORS.

(*Extract of a letter from M. G. A. Hirn to M. Faye.*)

RECENTLY I took notice of the effect of a flash of lightning which struck the lightning conductor of a house not far from my own, at Colmar. For some time I have hesitated to speak of it, because this effect was in some measure unimportant, but I have since thought that it is well to show that a lightning conductor, even though most faulty in its construction, may *sometimes* effectually protect a building.

This conductor was connected with a house 15 metres (=49.2 ft.) high; the rod was about 8m long, and was terminated by a conical brass point about 0m.25 in length, and 0m.01 in diameter at the lower part, screwed on to the rod. The conductor was a wire, hardly 0m.007 in diameter, and in pieces, with termical rings. The wire passed down through a hole in the moist ground and was connected with a large mass of iron about 0m.5 long. In every respect then this conductor was constructed in the most defective manner; a physicist would have certainly avoided taking refuge in the building to which it was attached during a storm.

On the 12th of the month (October) at 4h. 30m. in the evening a very violent storm burst forth; the clouds must have been very near the earth, for I was rarely able to count more than *two* seconds between the flash and the thunder. It was one of these flashes that struck the conductor just described. The disturbance was so great that the plaster was detached from the ceilings in several of the rooms. The total action of the discharge, however, was confined to the fusion of the brass joint for a length of about 0m.05, where the cone was about 0m.003 in diameter. No part of the current left the conductor, I have found no trace of the discharge in the small hole in which it terminated.

M. Melsens in his splendid work upon lightning conductors rightly remarks that, on account of the very feeble electric conducting power of water, a large area should in general be given to the part of a conductor which penetrates the ground, and it should be attached, wherever possible, to large masses of metal, such as the water-pipes which pass n the houses in great cities. The remarks made by Mr Mel- as on this subject are almost appalling when one thinks of the small area usually given to this part of the conductor. Perhaps I may here relate an experiment I made three years ago, and which completely confirms the views of M. Melsens. In the centre of a white-iron cylinder about 0m.25 in diameter, and filled with pure water to a height of 1m., I inserted a brass rod insulated in every part except where connected with the outer armature of a Leyden jar. At a distance (*varied* at pleasure) from the external circumference of the cylinder was a conductor terminating in a ball, which I placed in contact with the ball of the strongly charged Leyden jar. As soon as the distance between the ball and white-iron was less than 0m.02, the electric discharge instead of traversing the water in the cylinder, traversed the air in the form of a brilliant electric spark. The question here in point was that of an infinitesimal electric discharge, as compared with that of a lightning flash; the connection between the central conductor and the internal surfaces of the cylinder was much more perfect than that existing between the earth and the conductor of very many a lightning rod which has been supposed to have been well constructed, yet the spark passed through the air rather than the water. The sole fact of a discharge in the form of a spark at the point of a lightning conductor is certainly the proof of the faulty manner in which that of which I speak was constructed. We have then, it seems to me, every reason to wonder, and perhaps in general to feel re-assured, seeing that the discharge has not caused any serious accident.

In saying, "the sole fact of a discharge in the form of a spark," I certainly mention no new fact to physicists; it is nevertheless a fact which cannot be too much impressed upon the public, and especially upon persons, often very ignorant, who undertake the fixing of lightning conductors. During forty years of observation, I have not seen a flash of lightning strike a single one of the forty to fifty lightning conductors protecting the factories of Logelbach, and yet, during a storm they work actively. With some of the *uninterrupted* conductors I connected metallic wires terminating in an insulating helix, in the centre of which I placed a non-magnetised steel bar. Almost always after a storm passing at the zenith, these bars were more or less magnetised. In my dwelling-house, where my laboratory was, I was bolder. I separated the conductor by means of a thin leaf of a caoutchouc; the metallic wires, severed at the two ends, thus separated, penetrated into my workshop and terminated in a rheo-electrometer, which my friend M. Melsens had given me. During the greater number of the severe storms passing at the zenith, I saw the magnetic needle of the instrument oscillate; on several occasions I found the bar within the helix strongly magnetised, and yet I have never observed any appearance of fusion in the very thin copper wires serving to divide the current. *Comptes Rendus.*

METEOROLOGY.

M. FAYE, who during the last few years in his researches on tornadoes, has only been able to make thirty observations, considers of the utmost value, Mr. Finley's report on six hundred tornadoes observed in the United States in the present century. The number of observations appears to have constantly increased, but this does not necessarily indicate an increase in the number of these phemonena; but only that they can no longer pass unobserved on account of the rapid filling up of the country. These sudden storms are far more destructive than appears to have been believed. Statistics show that from February 1880 to September 1881, 177 persons were killed, more than 539 wounded, 988 houses demolished, and five villages of 100 to 1,000 inhabitants destroyed, entailing a loss of more than 2,000,000 dollars.

From a mechanical point of view, waterspouts, tornadoes, typhoons, and cyclones only differ in magnitude. They are all gyratory movements, descending, on a vertical axis, which originate in the upper currents of the atmosphere and follow their course.

From a meteorological point of view waterspouts and tornadoes are attendant phenomena of short duration formed in the centre of cyclones whose extent and duration are relatively enormous. The approach of a tornado, while yet at a distance of two or three miles, is announced by a black cloud from which a prolongation in the form of a funnel descends to the surface of the ground. At the bottom is the very small area, within which the destructive winds are concentrated. The gyratory motion in the tornado is always from right to left, *i.e.*, in a direction opposite to that of the hands of a watch. The velocity of rotation, although very variable, averages 570 ft. per second, or a little less than half that of a musket ball. The diameter of the tornado at the ground surface is variable; when it is only about forty-three feet it partakes of the character of a small typhoon; ordinarily it is from 984 to 1,312 ft.; beyond this circle the wind due to the tornado is no longer perceptible. The velocity of translation of these sudden storms varies from sixteen to eighty-two feet per second, averaging about fifty-six feet per second, or very nearly that of an express train. The direction of their motion is from west to east, generally from south-west to north-east; a tornado has never been known to take an opposite course. They may travel without reaching the ground rising or falling, and only causing damage when they touch the earth. They usually move in a straight line, but sometimes in a zig zag.

Tornadoes often occur in stormy weather when the atmosphere is hot and oppressive. They cause an immediate fall in the temperature, and often produce showers either before or after their passage. They sometimes show signs of an inherent electricity (the formation of balls of fire, &c.); at other times they show no trace of electricity. M. Faye finds all these phenomena in harmony with his theory.

The mechanical identity between tornadoes and cyclones enables us to perceive their meteorological difference. Besides the differences of dimension between these phenomena there are also differences in the length of travel of tornadoes (averaging eleven leagues, and often less) and of cyclones; the latter traverse enormous distances, seas, and continents, and leave in their train squalls, storms and showers; their time of duration presents characteristics no less distinct; cyclones lasting for several weeks and tornadoes for less than an hour.

Ten or twelve waterspouts may be produced at the same time in a cyclone, as in the case instanced by M. Lalande (11 simultaneous waterspouts).

Tornadoes occur most frequently in the months of April, May, June and July, and though they *may* happen at any hour of the day or night, the majority take place in the day-time, especially in the afternoon between four and six o'clock. Finally, M. Finley advises the taking of certain percautions to avoid the destructive effects of tornadoes. For this purpose he recommends that houses should be built square with a gable roof, and that subterranean places of refuge should be prepared within a short distance of all dwellings.—*Comptes Rendus.*

ON THE METHODS EMPLOYED FOR THE DETERMINATION OF THE OHM.

By G. Lippmann.

(*Journal de Physique*, July 1882, p. 313.)

The determination of the electro-magnetic absolute unit of resistance depends on the production of an electromotive force by induction. In most cases the induction gives rise to a variable current, and hence a complication is introduced by the induction of the current on itself. This necessitates a correction, the degree of accuracy of which it is difficult to estimate. In the recent experiments of Lord Rayliegh and Dr. Schuster by the British Association method, this correction amounted to 8 per cent. Moreover the resistance of a conductor of finite section, as is the case with a metallic wire, is only properly defined for constant currents, when the intensity of the current is the same for all points of a section of the conductor. Helmholtz has shown that with variable currents the intensity is greater at the periphery than at the centre. Hence the employment of constant currents is much to be preferred.

(1.) The first method satisfying this condition is due to Mr. Lorenz (1873). He employed a circular disc of copper rotating about its axis which is placed parallel to the lines of force produced by a circular coil concentric with the disc and traversed by a constant current. The electromotive force due to the induction will be along the radii of the disc, and can be received by rubbers placed at the centre and circumference. If i be the intensity of the current in the bobbin, w the angular velocity of the disc, the radial electromotive force is $C\,w\,i$, where C is a constant, which can be determined by calculation. The current i traverses the resistance r, whose absolute value is sought, and produces a difference of potential between the extremeties equal to $r.\ i$. By connecting the rubbers to the ends of r in such a manner as to oppose the electromotive forces the velocity w can be regulated until the two are equal, the equality being determined by a galvanometer placed in the circuit, which at the moment of equality will give no deflection Then

$$C\,w\,i = r\,i\,;\ \text{whence}\ r = C\,w.$$

The only difficulty presented in this method is the calculation of C, which depends on elliptic integrals, which cannot readily be evaluated to a known approximation.

(2.) The induction of the earth is also available for the determination of the ohm with constant currents. A vertical frame carrying a coil of wire is caused to rotate about a vertical axis with n revolutions per second. The circuit of the coil is not closed, but its extremities make contact at the moment of maximum induction with wires leading to the ends of the resistance r to be determined. In one of the leads Sir W. Thomson's astatic galvanometer is placed and used as a galvanoscope. A constant current is maintained through r and measured by a tangent galvanometer. As the disk rotates an electromotive force is induced in the coil, which is opposed to that of the current i. The latter is then varied by means of a rheostat placed in the battery-circuit until the galvanoscope gives no deflection. If S be the effective area of the coil, K the constant of the tangent galvanometer, and a its deflection, then,

$$r = \frac{2\,\pi\,n\,S}{K\,\tan a}$$

The quantities to be measured are precisely those occurring in the British Association method, but the correction for self-induction is avoided. This method has previously been suggested by Carey Foster and Maxwell.

(3.) The induction of terrestrial magnetism can also be used for obtaining a constant electromotive force. A copper disk similar to the one employed by Mr. Lorenz is rotated about an axis parallel to the compass needle. A radial electromotive force is produced, which can be received by rubbers placed at the centre and circumference. Using a similar arrangement to that described in (2), the resistance r is given by the equation—

$$r = \frac{n\,S}{K\,\tan a}$$

where S is now the area of the disk.

The electromotive force produced in this manner is very small, but by using a Thomson's galvanometer a degree of accuracy of 1 in 6,000 can probably be obtained.—*Proceedings of Inst. of Civil Engineers*, Eng.

Thermoscopic Method—In the *Comptes Rendus* de l'Académie des Sciences for October the 9th, 1882, Lippmann describes the following *thermoscopic* method for the determination of the ohm :—

The method differs from that employed by the eminent physicist Joule in that it does not recognize any measurement of quantities of heat nor a knowledge of the mechanical equivalent of heat J. This last is important, as, in Joule's calorimetric method, the final approximation is limited by the uncertainty which actually exists as to the precise value of J, the possible error being about 1-100.

The wire, of which the electric resistance r is to be determined, is placed in a vessel arranged like a calorimeter in the center of a space kept at a constant temperature. An electric current is passed through the wire, and its intensity i measured. By means of a thermometer, or sensitive thermoscope, plunged into the vessel, it can be easily ascertained when the vessel has realized a steady temperature under the heat liberated by the current. Having done this, the current is broken, and friction is then produced within the vessel containing the metallic wire. The heat generated by the friction takes the place of the heat previously caused by the electric current, and is so regulated that the steady temperature of the vessel acquires the same value as before. Hence, r may be determined from the equation $r\,i^2 = T$, T being the work empended. It is scarcely necessary to add that the friction apparatus should be firmly fixed in the vessel, even when it is not working, and should be supplied with an arrangement for measuring T ; in practice, it is easier to obtain the heat first by friction, and afterwards to regulate the intensity i so as to regain the same steady temperature. Finally, it may be advantageous, in the case of large apparatus, to observe the rate of heating instead of the temperature.

Joule's method depends upon the measurement both of i and of a mechanical work, viz., the work developed at the time of the evaluation of J ; and, further, it implies two calorimetric measurements, designed to mutually eliminate one another in the final result, viz., the measurement accompanying the determination of J, and that accompanying the passage of the electric current; these intermediate measurements introduce causes of error and corrections, due to the imperfections of the calorimeters by which they are made. This difficulty is avoided by the present method, as the work T and the electric energy $r\,i^2$ are expended in the same caloriscopic vessel so that it is not necessary to know the amount of heat liberated in the vessel.

THE COMET.

I send a few sketches (page 22 and 23) and a brief account of the comet Cruls. I found the comet at 11 h. a.m. September 22, by sweeping the sky near the sun with the 10-inch refractor of the Observatory of Palermo. It was not an easy object to find ; it seemed but a point with a surrounding nebulosity, and a trace of tail directed to the south-west.

On the following morning the comet had the form (observed by Prof. Zona and myself) of Fig. 1, and preserved it until September 27 ; the tail was very splendid, inclined 50° to the horizon (that is to say, nearly parallel to the equator), a little convex to the south ; the visible length in the glare of dawn and moon was 6°, and then 10°; the breadth at the top was 40', and then 1° 18'. The nucleus was round and very briliant, with a yellowish light.

The spectrum was formed of the linear continuous spectrum of the nucleus traversed by a large and strong line, that of sodium (D) ; by enlarging the slit of the spectroscope, I saw a globular, monochromatic image of the nucleus and coma. Besides the line of sodium, many others were present, but my spectroscope not having a micrometer, I did not determine them ; I observed a band in the red, a line in the yellow near and after D, two others in the green, and an enlargement of the continuous spectrum of the nucleus in green and blue.

From the form of Fig. 1, the comet passed to that of Fig. 2 till October 1. The tail was more curved and diverging, inclined to the horizon a little more than 45°, the length was near 15°, the breadth at the top 1° 48' ; the south edge was very much stronger and brighter than the north edge, an obscure streak seems to divide the comet through the whole length. The nucleus was less luminous ; it appeared double, and lengthened to 25", having a very brilliant jet directed to the sun.

The comet was not now as yellow as before, and corres-

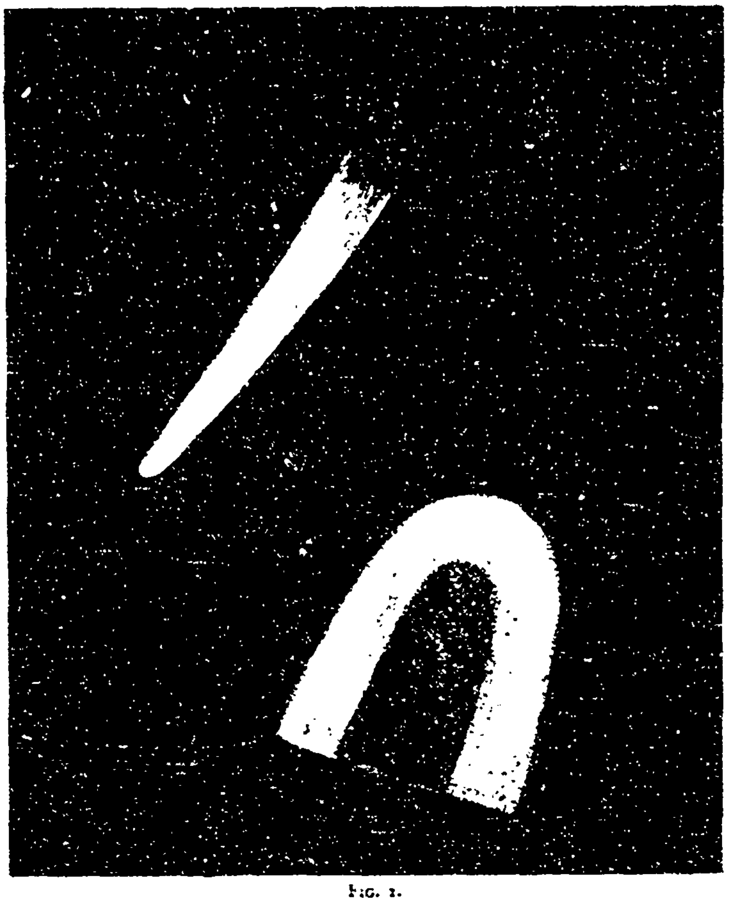
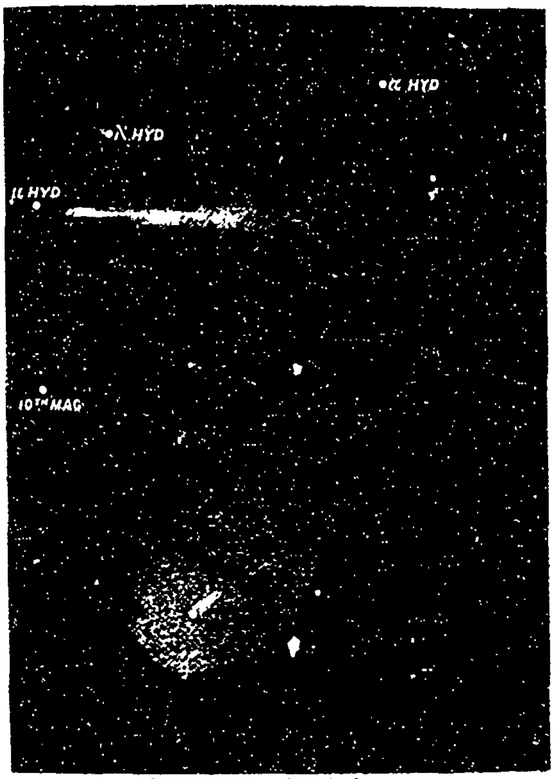
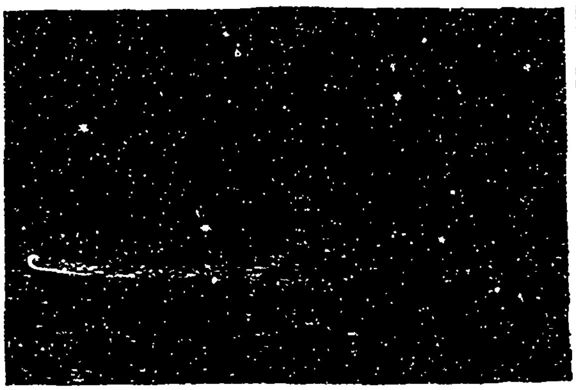


Fig. 1.

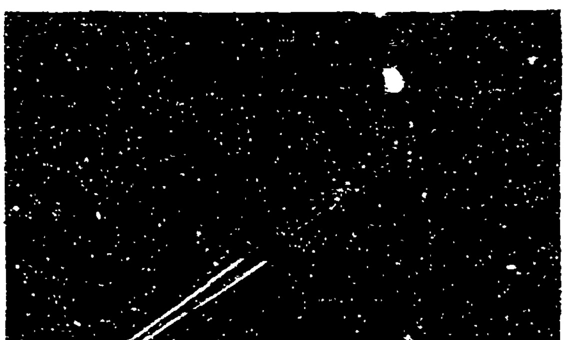
Fig. 2.



OBSERVED BY G. M. SEABROKE.
5 a.m. October, 23, 1882.



OBSERVED BY J. HERSCHEL.



OBSERVED FROM CANNES BY C. J. B. WILLIAMS.
Between 5 and 6 a.m. October 21, 1882.

FIG. 3.

spondingly in the spectrum the sodium line was very reduced and little luminous, but the usual three bands of the hydrocarbons—yellow, green, and blue—were very conspicuous.

From October 1 to the present time the comet approached the form of Fig. 3, which I observed this morning; around the nucleus and very excentrically to the north, it is a faint envelope; at the top of the south edge a sort of horn issued; the north extremity is 1° distant from α Hydræ. The length of the tail is 17°, the breadth 2° 48′.

The nucleus is much diminished and little luminous, and the colour of the comet almost white.

Besides the linear spectrum of the nucleus, the three bands of hydrocarbons extend 5′ round the nucleus.

The spectrum of the tail is continuous, and visible to the end.

It is remarkable that the changes of the spectrum (according to Dr. Hasselber's experiments) enabled me to predict that the comet had passed the perihelion before the orbit was calculated.

The beautiful sky of Palermo permitted me to observe the comet Cruls every day except October 5.

Observatory, Palermo, October 11 A. RICCO

THE GREAT SOUTHERN COMET OBSERVED AT THE IMPERIAL OBSERVATORY AT RIO.

Memo. of M. Cruls.

On the 10th of last September M. Cruls received information of the presence of a comet in the east, visible to the naked eye before sunrise. It was not till the 12th, at about 5h. 15m. (mean time at Rio), that it was seen at the observatory. The sky remained clouded in the east towards the morning until the 22nd. The comet, however, continued to be visible in other parts of Brazil, and telegrams apprised us that it had been seen in broad daylight and a few degrees from the sun on the 18th, 19th and 20th.

At last on the 25th of September a clear sky allowed it to be seen in all its brightness. At four o'clock in the morning a portion of the tail rose above the horizon, rather like a column of fire than a pencil of light. It was nearly vertical, and of a well-defined conical form, measuring 40' at its base and 1°30' in its widest part. The sight of this column of fire, to which the lower atmospheric layers gave a yellow-ochre tint and which was reflected in the waters of the Rio, was a magnificent spectacle.

The telescopic examination of the tail, in proportion as the parts nearest the nucleus became visible, presented very plainly the appearance of a stream of extremely vivid light in which one could distinguish threads more luminous than their surroundings. Then the nucleus arose and appeared extremely bright, with a diameter of about 60"; it was enveloped by a stream of light, and on both sides behind the two luminous threads spread out and combined to form the beginning of the tail whose luminous intensity was still considerable at a distance of 10° to 12°. However, in the axis of the tail the tint was more sombre and was even almost destitute of light immediately behind the nucleus for the length of ½° ; this peculiarity called to mind the vacuum left behind a projectile traversing space with a sufficiently great velocity. The tail again was remarkable by its curvature, the convexity being turned towards the south, the sharp and well-defined convex edge formed a contrast to the concave edge whose luminous intensity was vague, blurred, as if of a vapourous nature. The luminous pencil of the tail, after being sensibly widened from the nucleus for a distance of 12° then suddenly terminated ; but a portion of this tail was prolonged with other characteristics, on the convex side a very pale luminous pencil of a width about 2·5th of the thickness of the tail at its free end, stretched about 15°. M. Faye even believes that the question here is that of a comet having a second tail.

The nucleus is surrounded by a coma very slightly luminous, about 20' in width along a line passing through the nucleus and normal to the solid of the tail.

The spectrum of the extremely large nucleus could be clearly distinguished from the red to the violet, from the line B to the line G, showing, although feebly, a certain number of Fraunhofer's lines The luminous intensity was such that with a slit of ½mm the line D of sodium, although not divided, was very fine and the carbon bands allowed the blurred rays which composed them to be perfectly seen. The spectrum of the tail was the spectrum of the nucleus, but of less intensity.

SPECTROSCOPIC OBSERVATIONS UPON THE GREAT COMET (Cruls).

By the observations of Mr. Lohse in Scotland and of MM. Thollon and Gouy at the observatory at Nice, on the 18th of September last, it was established beyond doubt that brilliant rays of sodium were seen in the spectrum of the great comet at that time and that those rays were slightly displaced towards the red. The dispersive power of the mirror and spectroscope employed in the Nice observations was too small, and, therefore the more faint rays observed by Mr. Lohse in the green, could not be distinguished with certainty ; for, under the circumstances, the spectrum of the diffused light was much too sharp not to conceal them, as well as the bands of carbon. These simultaneous observations agree in a most satisfactory manner and should consequently inspire confidence.

Until the 9th of October MM. Thollon and Gouy could not make any further spectroscopic observations by reason of the unfavourable condition of the sky. On this day, an hour before sunrise, it was ascertained that the sodium as well as the other bright rays had disappeared. Only the usual four carbon bands were visible ; the violet band was perfectly distinct, although very feeble ; the others were very bright, especially about the nucleus. At the same time the latter gave a continuous, narrow spectrum, in which the observers believed they saw a large number of black and bright rays.

From the 9th to the 16th of October no observations were made on account of the bad weather. On the 16th at four o'clock in the morning, the sky being perfectly clear, the spectrum of the comet shewed the same character as on the 9th ; the violet band had nearly disappeared, and the continuous spectrum given by the nucleus was considerably fainter. The bands had diminished in length but their brightness had scarcely changed. The spectrum of the comet, compared with that of an alcohol flame, showed the most striking resemblance to the latter. Is it necessary to add that this resemblance by no means implies the presence of alcohol amongst the constituents of the comet? It is known that all the compounds of carbon give the same bands, and alcohol was selected because of the greater ease and advantage which its employment seemed to offer.

On the same and following days the integral spectrum of the comet was observed by means of a spectroscope without the slit. This somewhat bright spectrum was continuous and shewed no trace of bands, which proves that the larger portion of the emitted light was white, probably the diffused light of the sun.

The disappearance of the sodium and the other bright rays observed by Mr. Lohse proves that, under ordinary circumstances, the spectroscope cannot give a complete analysis of cometary matter. It is very possible, even very probable, that this matter is composed of the same elements as that of aerolites. On the other hand, if the temperature of the comet is sufficiently high to produce the spectrum given by the compounds of carbon, it should be sufficient to produce that of sodium, which is contrary to observation. These considerations, which have been long discussed, have led again to the electric theory of comets. In fact, it is known, that if the electric fluid of a Holtz machine, without condensers, is made to pass through a gaseous carburet, the gas takes fire and gives the carbon bands ; if it holds any metallic compound in suspension, in the form of fine dust, it will always give the same bands without shewing any ray of the metals held in suspension. Probably there is some analogous phenomenon in connection with comets, and hence, with regard to their chemical composition, they would not present a strange anomaly and would not differ from other bodies circulating in our solar system.

M. Chalois who makes the calculations at the Nice observatory, and is a skilful draughtsman, joined us in order to observe and sketch the peculiarities exhibited by this brilliant comet. On the 16th of October, while observing with a three-inch finder, he discovered that the whole of the front portion was surrounded by a very faint kind of sheath, invisible to the naked eye, clearly outlined, and extending 7° or 8° in a direction opposite the tail. The photographs taken at the observatory reproduce, according to his designs, which were very carefully verified by us, the appearance of the comet on the 9th and 16th of October ; it was taken from 23° to 25° in length.

CRITICISM ON DR. SIEMENS' SUN THEORY BY M. FAYE.

It is well known that under the action of light and with the intervention of the chlorophyl of vegetables, vapour of water and carbonic acid are decomposed at ordinary temperatures and are restored to a combustible form, carbon and hydrogen being differently combined. Siemens finds that if the vapour of water and carbonic dioxide be extremely rarefied (with a density say of 1-1800), the action of the sunlight will produce the same decomposition without the aid of any other intermediate agent. Siemens, assuming the results of his experiments to be complete and decisive, enunciates the following theory :—" Space contains, besides minute masses of solid matter (meteors), an exceedingly rare atmosphere (density=1-2000) of burnt gases (vapour of water and carbonic acid) mixed with inert gases, ozote &c. These gases are partially transformed into combustibles by the solar light, are drawn into the sun, are there burned afresh and sent back again into space. This immense source of heat continually renews itself, and nothing is lost save as much of the heat of radiation as is absorbed by the cosmic medium with a density of 1-2000 only." This, for the physicist, as M. Faye remarks, is an almost absolute vacuum, since the electric spark can no longer traverse it, but not so for the astronomer. The rectifications required by the resistance of the surrounding medium in the trajectories of the heavenly bodies which move, say, sixty times as fast as a cannon ball, would be twice as great as those found necessary in the case of the cannon balls, even though the density of the surrounding medium be reduced to 1-2000, and this not after the lapse of a few centuries or a few years, but after a few seconds. In the second place, the distinguished English physicist seems to have neglected one important consideration, *viz.*, the amount of matter his theory would add to the sun. Under the influence of attraction this matter would be added to the already existing stars, but especially to the sun, and their mass would continually increase. Thus, a litre of air containing the desired proportion of vapour of water weighs at least 1 gramme at the ordinary pressure At a pressure of 1-2000, a cubic metre will weigh .0005 kilogrammes. This being taken for granted, and the solar system limited to a sphere embracing all the planets up to Neptune, the weight in kilogrammes of the very rare matter added by the hypothesis would be 4·3 × (64,000,000 × 24,000 × 30)³ × .0005.

The actual weight, in kilogrammes, of the sun is 4·3 × (64,000,000)³ × 5.6 × 324,000.

The first weight is 100,000 times greater than the second. However, Siemens' theory would add 100,000 times the mass of the sun to the mass which has hitherto been so carefully determinedby the method of celestial mechanics.

Faye remarks in conclusion that, although Siemens' fundamental experiments are valuable, his theory is of no importance from an astronomical point of view. (*Comptes Rendus.*)

DR. C. W. SIEMENS' REPLY TO MR. FAYE'S OBJECTIONS TO HIS SUN THEORY.—(*Comptes Rendus.*)

"M. Faye, while generally approving of the physical portion of my investigations, questions their application to astronomy for the following reasons :—

1. That the pressure of a universal gaseous medium, at a pressure of 1 2000 of an atmosphere, would offer an excessive resistance to planetary motion ;

2. That the vapour, thus distributed, would be gradually attracted to the sun and would tend to produce a considerable increase in its mass.

In the first place, with respect to M. Faye's second objection, permit me to remark, that the degree of diffusion I have assumed is such as to ensure the permanence of the statical equilibrium between the forces of expansion and diffusion on the one hand, and the attraction towards the sun and the celestial bodies on the other. If such an equilibrium were not established, M. Faye's objection would naturally completely overthrow my theory. Besides, I am willing to admit that if Mariotte's law respecting the expansion of permanent gases could be applied indefinitely, the pressure of the interplanatary gaseous medium would be lowered almost to a degree beyond conception, but it seems to me, from considerations based upon the dynamical theory of gases and from the behaviour of gases, as demonstrated by M. Crookes, in *extremely rarefied tubes*, it seems to me, I say, that there exists no *a priori* reason, justifying the rigorous application of the law to vapours beyond the confines of our atmosphere and of that of the sun. As regards M. Faye's first objection, I admit that a density of 1-2000 of that of the atmosphere would have the consequences which he so justly establishes, and I remember to have said that, if the results of my experiments upon dissociation of vapours by solar energy, are accepted as demonstrated and if it be assumed that the stellar space is filled with a vapour at a pressure *not exceeding* 1-1000 of an atmosphere, which *corresponds to the greatest* rarefaction I have obtained in my experiments, then there must ensue a dissociation of that cosmic vapour by the radiation of the sun. Nevertheless, it must be remarked that this observation only relates to the physical phenomena discussed in my experiments, and it is evident that, if the dissociation of the vapour of water and of the carbon compounds is effected, by the direct radiation of the sun, at a pressure as high as 1-1000 of an atmosphere, with far greater reason would it be effected in the much more rarefied medium.

In another portion of my paper, in which I apply my hypothesis to comets, I assume that they represent, even at their perihelion, a gaseous medium, at a density of 1-3000 of that of an atmosphere only, and that this density is sufficient to cause incandescence by compression. This assumption at least proves indirectly that I considered stellar space to be filled with a vapour at a pressure much less than 1-3000 of an atmosphere, starting from such a medium, (in the absence of data derived from experiment and observation), as from an intensely rarefied state, without fixing any limit to this rarefaction.

Afterwards, new facts of observation tended to confirm my hypothesis of a stellar space filled with rarefied matter analogous to that realized in vacuum tubes. The equatorial prolongations *of the* solar atmosphere, observed in America during the eclipse of 1859, seems to prove the existence of a substance stretching out from the Sun for a distance of several millions of leagues and rendered visible, beyond doubt, by solid particles, partially *illuminated by the* reflection *of the solar light* and partly by electric discharges towards the Sun.

My hypothesis has met with a more direct confirmation in the remarkable spectroscopic *investigations communicated by* Capt. Abney last August in Section A of the British Association, which proves the existence between our atmosphere and that of *the sun,* of carbon compounds at a low temperature which may be easily and distinctly observed, and which are probably analogous to ethyle. Professor Langley's observations in America with his bolometer, although made for another purpose, tend to confirm the results obtained *by* Capt. Abney upon Mount Riffel. To these proofs may be added the interesting observation of Professor Schwedoff (as yet unpublished, and communicated to me by *Professor Sylvanus Thompson*), according to which, large hailstones of a cosmic origin have sometimes fallen upon the earth. This observation, *however, requires confirmation.*

Assuming that these observations are founded on facts, physical considerations render it possible to determine approximately the actual density of the stellar vapour, which, in this case, depends upon the temperature of the space. From Gorschow's observations on the 30th of November, 1871, of a temperature of 63 ° C. in the Arctic regions, it follows that the temperature of the stellar medium (*which, if composed of* a vapour, must have the power of intercepting heat rays), must be between 63 ° and the absolute zero (273 °); the solar radiation must maintain in it some temperature, or, at least, such a temperature that the dissociation of this medium goes on very actively. To Regnault is due our knowledge as to the density of vapours at different temperatures, but his investigations are not continued below 32 ° C., and his formulæ could not be rigorously applied below that point, nevertheless they enable us to estimate approximately what the density of a vapour may be at still *lower temperature ; hence we* are led to believe that at 130 ° the density of the vapour of water does not exceed 1-5,000,000 of that of the atmosphere. *Further, let us assume that the gaseous mass* which fills interstellar space only contains 1-5 of its volume of aqueous vapour, the remaining 4-5 consisting of hydro-carburets, carbonic acid, and azote, the total pressure of the vapour would not exceed 1-1,000,000 of an atmosphere.

These vapours would traverse space with a velocity probably equal to one-half of the tangential velocity at the sun's surface or to 1 k.m. (5·8mile) per second. *It could be easily shewn,* that a column of these dissociated gases, travelling towards the polar surfaces of the sun with this velocity, and taken at a distance of 5,500,000 k.m. *from the sun* (the mean distance of mercury, the nearest of its planets), would present toward the sun a section of flow equal to 140,000,000 millions of square kilometres, much more than enough to supply the necessary substance which will yield by combustion the heat required to maintain the solar radiation.

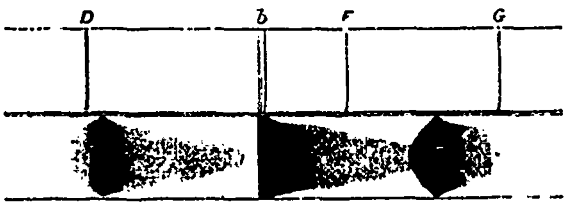
Perhaps the distinguished Director of the "Bureau des Longitudes" *may consider that a gaseous medium of a density* equal at most to 1-1,000,000 of that of our atmosphere would still impede the movements of the planets in a degree incompatible with the *facts obtained* by astronomical observations ; if this were the case, it would suffice to assume, for this medium, a still lower temperature and consequently a more attenuated rarefaction for interstellar gaseous matter.

(Comptes Rendus, 1882, Extract from letter to M. Dumas.)

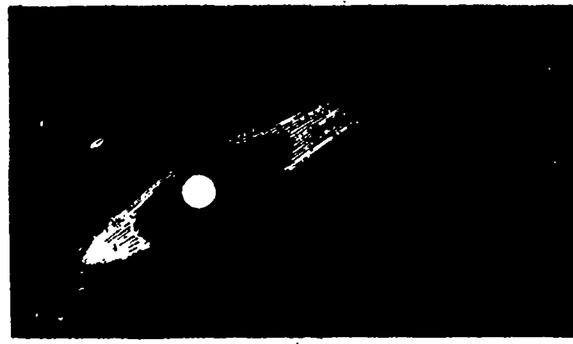
THE TRANSIT OF VENUS.

BY ALEXANDER JOHNSON L.D.

Astronomy has received an unusual share of public attention lately in consequence of the appearance, first, of the great comet which was conspicuous in heavens for so many weeks; secondly, of the great sun-spot accompanied by the "magnetic storm" which so seriously deranged telegraphic communications; and thirdly, of the Transit of Venus. Concerning this last there are numerous topics of general public interest, a few of which are here considered :—

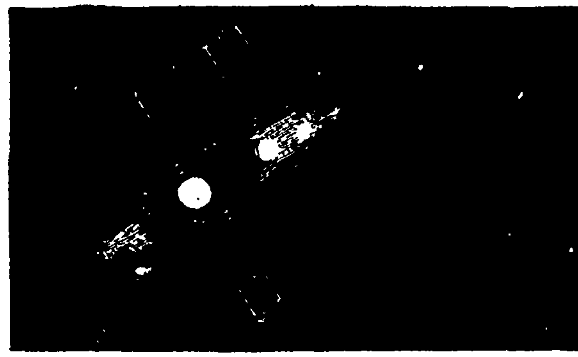


No. 1.—Spectrum of Crul's Comet, October 15 and 16.



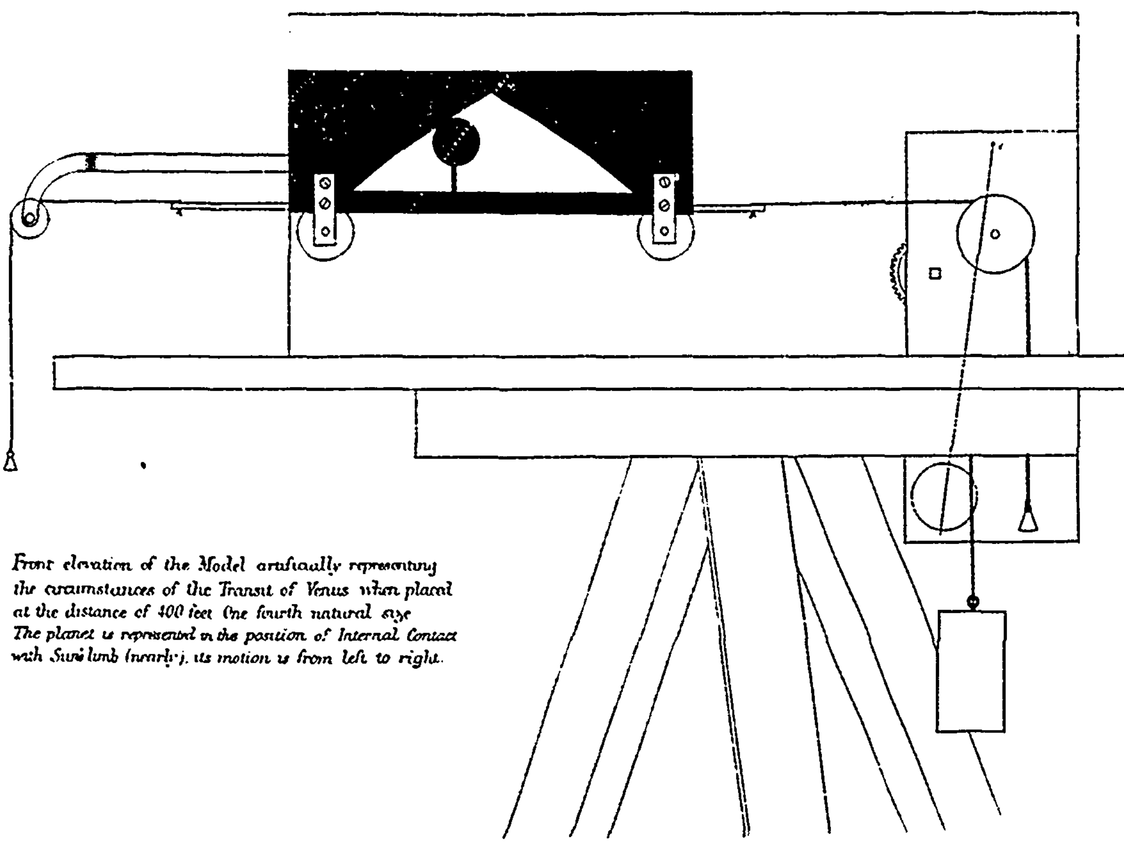
No. 3.—Nucleus of Comet, October 25, as seen in 26-inch Equatorial.

No. 2.—October 10, 1882.



No. 4.—Nucleus of Comet, Nov. 5, 1882, as seen in 26-inch Equatorial.

Transit of Venus 1874 Dec 8.



Front elevation of the Model artificially representing the circumstances of the Transit of Venus when placed at the distance of 400 feet One fourth natural size
The planet is represented in the position of Internal Contact with Sun's limb (nearly), its motion is from left to right.

TRANSIT OF VENUS,

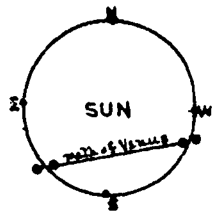


FIG. 1.
THE FOUR CONTACTS.
PATH OF VENUS AS SEEN FROM CENTRE OF EARTH.

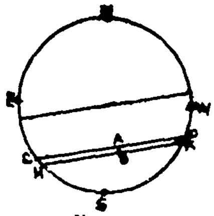


FIG. 2.

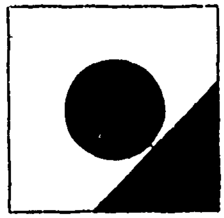


Fig. 4.

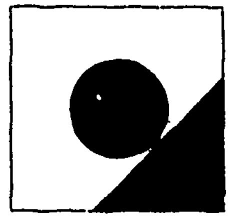


Fig. 5.

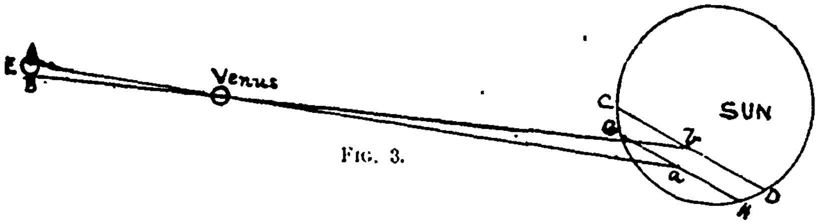
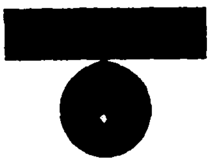
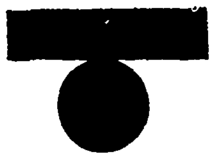


FIG. 3.

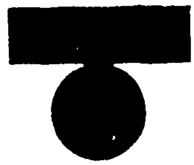


Egress Fig 6.

Egress Fig 7.



Egress Fig 8.



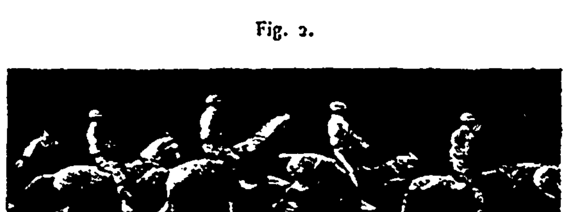
Ingress Fig 9.

Ingress Fig. 10.

Fig. 1.

Gymnaste militaire au pas de parade.

Fig. 2.



Cheval sautant un obstacle.

The transit or passage referred to was simply the passage directly between us and the sun, of the planet Venus, which had previously been seen shining so brightly in the western heavens shortly after sunset, on the eastern or left hand side of the sun. A black spot, less in diameter than the thirtieth part of the sun's diameter, was seen even without a telescope, but through a smoked glass, or even without this when a slight haze covered the sun, to cross the lower part of the sun's disc. This happened on December 6th last, and a part of the passage was visible at Montreal for about an hour. The beginning of the passage ("External contact at Ingress") must have occurred according to calculations about nine minutes past nine a.m., Montreal time. The planet was fully on the disc, and its edge touched the sun's edge, or, what is called "Internal contact at Ingress" took place about 9h. 30m. a. m. The passage then continued across the disc until 2h. 51m. p.m., when the edge of the planet was again just touching the edge of the sun (the planet being still fully on the sun's disc). This latter is called "Internal contact at Egress." Venus continuing to move onwards passed entirely off the sun's disc ("external contact at Egress") about 11 minutes past three p. m., (See fig. 1.) but, unfortunately, clouds covered the sky at these moments and none of these contacts was seen.

The diagram exhibits the position of the path of Venus across the sun's disc by referring it to the north and south points of the disc, these being the points where a declination circle through the centre cuts the disc—or they may be regarded as the points where the disc is cut by the meridian when the sun's centre is on it. At that time they are the highest and lowest points of the sun respectively, but not at other times of the day. This may be made obvious by putting a circular piece of paper like the diagram in the sun's place on a celestial globe placed in the proper position, so that the brass meridian may be over these points; then turning the globe to the position for half- past nine o'clock it will be seen that Venus enters on the sun's disc very near the lowest point. The calculated angle from the north point for contact at Ingress was 145° towards the East; and for contact at Egress was 114° towards the West. As seen in an inverting telescope the whole figure would have been turned upside down.

The same phenomena would have been visible at very nearly the same instant over a great part of Canada if the weather had been favorable, occurring only from two to six seconds later at Ottawa, and a few seconds later still at Toronto, for example. But although at nearly the same time absolutely, the hours and minutes which denote the local time, would be, of course, different. The difference between Montreal and Toronto time, for example, being about 23 minutes we shall have to subtract 23 minutes from the times given above in order to find the local times for Toronto. So for other points of Canada, the local times corresponding to the Montreal times given above were the times for observing the four contacts mentioned. Canada was, however, very unfortunate in the weather. Out of thirteen observing stations, only four are reported to have been able to see any of the contacts.

The parts of the world where the transit was visible (weather permitting) in whole or in part are given in charts in the *American Nautical Almanac* for 1882. These show also the times of contact at different places. But these times whether taken from the charts or calculated from the formulæ in the British *Nautical Almanac* cannot be relied on within two minutes. Hence, indeed, arises the necessity of observation. In fact, as the data employed are somewhat different, the times as given by the chart, of the one almanac, and the formulæ of the other, do not always agree exactly, as may be found by any one who chooses to make the comparison. A further comparison of the times actually observed with the times announced beforehand can hardly fail to be interesting.*

But why was this transit so eagerly observed by astronomers? What is the great problem to be solved which would justify the expenditure of so much time and thought, and toil and money by almost all the civilized nations of the world?

It may be described as a problem in surveying on the grandest scale. When a farmer or the owner of a large estate gets his land mapped out, and its size ascertained exactly, the advantages as well as the satisfaction arising from it are obvious. So, on a higher scale, are those of the Ordnance Survey of Great Britain or the like work for any other national territory. Rising still higher, we come to those surveys which have had the mapping out of the whole earth and the determination of its size for their object.

Higher again, we consider the earth as one body in the solar system, which system is to be accurately surveyed. Beyond this comes the step which leads us from the solar system itself to the dimensions of the visible universe. But with this our present subject has no immediate concern, although there is a close connection.

Confining our attention to the solar system we may, from one point of view, compare our knowledge of it to that of an estate or territory of which a very accurate map has been made, so far as the relative positions and dimensions of all the parts are concerned, but on which from some oversight the scale has been inaccurately drawn. Suppose, for example, it was uncertain whether a mile was represented by an inch or an inch and a quarter. (This, however, would be an enormous exaggeration of the uncertainty in the case of the solar system.) The result of this, of course, would be that the actual distance in yards or miles between any two points, or the number of acres in any given area, could not be ascertained. Similarly for the solar system we know the relative distances, the relative sizes, and even the relative weights of the planets and the sun; but there is a good deal of uncertainty about the scale, and hence we cannot say with certainty what is the actual number of miles in any required distance. This is, however, due not to any oversight, but to the difficulty of the measurements required to enable us to lay down

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* The following are the formulæ of "The Nautical Almanac,"

"For any place on the surface of the Earth, the Radius being r, the Geocentric North Latitude l and East Longitude l', the Greenwich meantime t of *first external contact* may be computed by the formula,

"Dec. 6, $1^h\ 55^m\ 57^s + [2.5471]\, r \sin l - [2.4789]\, r \cos l \cos (l' - 87° 53'.3)$. The *first internal contact* by

"Dec. 6, $2^h\ 16^m\ 18^s + [2.5850]\, r \sin l - [2.4767]\, r \cos l \cos (l' - 85° 55'.9)$. The *last internal contact* by

"Dec. 6, $7^h\ 51^m\ 46^s - [2.3129]\, r \sin l + [2.6454]\, r \cos l \cos (l' - 138° 45'.7)$. The *last external contact* by

"Dec. 6, $8^h\ 12^m\ 9^s - [2.2397]\, r \sin l + [2.6337]\, r \cos l \cos (l' - 135° 9'.4)$.

The quantities in brackets are the logarithms of seconds of time.

the scale. Our unit of measurement is the distance from the sun to the earth, and this has never yet been determined in miles to the satisfaction of astronomers.

How then can the distance of the sun be found by observing the passage of Venus across his face? To explain this simply, it will be better to consider not the distance of the sun, but the diameter of the sun in miles as the object of search. If either can be found the other can be calculated from it by a simple proportion (which need not be here discussed) so that the above question becomes—"How can we, by observing the passage of Venus across the sun's disc, find the diameter of that disc in miles?" A general explanation is all that will be attempted here. Referring again to the illustration of the map, but letting the map now correspond not to the solar system, but to the sun's disc only, it is obvious that if we knew the actual distance in miles between any two points represented on the map, we could readily find the distance in miles between any other two points, the map being supposed accurately drawn. For example, if we have a map of any city, Montreal for example, carefully drawn, but without any scale attached, we could by knowing the distance between any two parallel streets, such as St. Catherine street and Dorchester street, tell the entire length of the city, because the ratio of this length to the other is given by the map. Similarly in the case of the sun's disc, if we know 1° the distance in miles between any two parallel lines on its surface, and 2° the ratio of the whole diameter to this distance we evidently can find the diameter. The problem thus but consists of two parts:

1° The distance of the two parallel lines in miles.

2° The ratio of the diameter to this distance.

If we reverse the order of these we may say that they correspond to

1° Drawing our map, but without knowing the scale.

2° Finding the scale.

The map, however, we have to draw of the sun's disc is a bare outline. If we draw any circle to represent the sun's disc, we have merely to lay down on this circle a diameter and two other lines parallel to one another. (See Fig. 2.)

H K, C D, Paths of Venus as seen from Northern and Southern Stations. A B., distance between the 1 chords.

But how are the lines on the sun's face to be selected? This may be explained by another illustration. Go into a room with a gasalier hung from the ceiling, sit down on a chair, look at one of the glass globes, and notice what part of the opposite wall it hides from you, then sliding the chair in a straight path across the room observe that the part of the wall hidden from time to time during the motion will form a line on the wall. Next, stand up, and moving along the same path on the floor you will, of course, see that the glass globe hides a different line on the wall. It is clear that the distance apart of these two lines depénds on the difference of the heights of the eye in the two cases and on the relative distances of the glass globe from the eye and the wall. Here the wall corresponds to the sun's face; the glass globe corresponds to Venus, and would correspond better if it moved across between you and the wall, instead of compelling you to move in order to produce the same effect. Another illustration might be this: Hanging up a large circular sheet of paper against the wall to represent the sun, and getting a friend to pass a cent steadily between it and your eyes while you, at a considerable distance, are on the first occasion sitting down, and on the second standing up, you will see two different lines traced out.

Let the observers be at A and B, Fig. 3, the two extremities, suppose, of the diameter of the Earth (E) which is perpendicular to the ecliptic. Then, when the observer A sees the centre of Venus projected on the sun's disc at a, the observer at B will see it at b; and the lines C D and G H will represent the lines or the paths that appear to be described across the disc. The distance apart in miles of these two lines can be found without any great difficulty, because it depends obviously on the distance between the stations of the two observers, which is easily found, and on the known ratio between the distances of Venus from the Sun and from the Earth, about $2\frac{1}{2}$ to 1. Thus one part of the problem is solved, viz., that corresponding to measuring the distance between two parallel streets on the map of Montreal.

The most difficult part, however, remains, viz., that which corresponds to finding the ratio on the map between the length of the whole city and the distance just mentioned. We have to find the ratio of the whole diameter of the sun to the distance between the two lines on its surface that have been observed. The observations for this purpose are simply enough stated. The two observers already mentioned have only to notice the exact duration of the passage in each case.

PREPARATIONS AT McGILL COLLEGE FOR OBSERVING THE TRANSIT OF VENUS, DEC. 6th 1882.

At the time of the transit of 1874 the College was very poorly supplied with astronomical instruments. It had a refracting telescope of $2\frac{3}{4}$ inches aperture, which, together with a small transit instrument and chronometer for taking time observations, constituted practically its whole equipment. In order to call public attention to our wants, I wrote a letter, therefore, to one of the daily papers, pointing out the importance of the coming transit of 1882, and the need of proper instruments to observe it; but this had no immediate effect. About the end of the year 1878 some of our citizens who felt an interest in astronomy held two or three private meetings to consider the possibility of establishing a public astronomical observatory as an independent institution governed by trustees. In accordance with a request from them, I wrote a letter on the subject which was inserted in the newspapers in January, 1879, and in this I again directed attention to the approach of the great astronomical event. The times were apparently unpropitious. There was no public result.

In September, 1879, however, Mr. Blackman, B.A., of Yale College, U. S., then a resident of this city, made a very handsome donation to the College of astronomical instruments, including a $6\frac{1}{4}$-inch equatorical of 7-ft focal length, a large transit instrument, an excellent mean time clock, a sidereal clock and chronometer. Subsequently, two good but smaller telescopes of $4\frac{1}{4}$ and 4 inches aperture were placed in the College, one left to the Trafalgar Institute by the late Donald Ross, and committed for safe keeping to McGill College, and one lent by G. A. Drummond, Esq. As far as instruments sufficient for transit observations were concerned, the College was now well supplied, for with no very great additious it could have equipped two or three observing stations, besides Montreal. But these other stations would have involved considerable expense and it was necessary to provide for this—to allow so much "observing plant" to lie unused while Canada generally was not too well supplied, would not have been creditable to Montreal. In February, 1880, I read a paper before the Athenaeum Club of this city, explaining the state of the case, and afterwards another paper on the same subject in May, 1881.

Subsequently the question was taken up by the Corporation of the College and a committee was appointed to consider the means of providing for the expenses and other matters. In their name I wrote to the Astronomer Royal explaining our situation and asking for information as to the expenses of stations in 1874, and advice and instructions generally, since any observations must be made in concert with those of other observers. The letter was submitted by him to the Committee of the Royal Society who have charge of the management for all the British Transit of Venus expeditions, and in his reply he gave us ample information which was of great service, in addition to sending the report of the British Observations of 1874, which had not long been published, together with the "Instructions to Observers" in that year. At a later period five copies of the "Instructions" for 1882 were sent out.

(To be continued.)

ANIMAL PHYSIOLOGY.

The typographical reproduction of photographs. An indispensable accompaniment of the applications of photography to physiological experiments is the exact reproduction of the images obtained, the facility with which proofs can be struck off, and the possibility of incorporating them with printing; these requirements have been fulfilled in a very satisfactory manner, by M. Petit's process of "*simili-gravure.*" Two specimens of these proofs will enable the reader to estimate all the resources of photography as applied to certain scientific demonstrations. Fig 1 (page 29) shows the successive positions of a man marching, and was obtained by the process of taking successive impressions upon one plate. The imperfections of the proof are almost wholly due to defects in the original stereotype. Thus, at the lower part, the background is not sufficiently dark and the outlines of the legs and feet are not well defined. This is due to a faultiness in the screen before which the photographs were taken; the lower part of the screen did not comply with the conditions of absolute blackness as well as the upper part. A vertical white band may be observed upon the fifth image. This band is the picture of a post which supported the screen, and may be made to disappear by an alteration in the arrangement. The clothing necessarily interferes to some extent with the exact representation of the bodily movements. The proof, however, such as it is gives much information. It shows that in every complete step the body assumes different positions, that the step occupies $\frac{6}{10}$ part of a second, and that the head during the same time makes two vertical oscillations; that the arm makes a wide oscillation in a direction contrary to the movement of the corresponding leg. The successive phases of the displacement of the foot and leg can be easily followed, and the actual value of the displacement between two consecutive images, *i.e.*, in $\frac{1}{10}$ of a second can be determined with a compass.

Fig. 2 represents a white horse clearing a fence. It was an old Syrian animal, and an expert can easily recognize the signs of age. The arrangement of the screen had been improved in this series of photographs, and the details come out better in the lower part. It is needless to say that the method is not yet perfect, but an important point has been reached in the application of photography to the illustration of science.

NOTES.

The *Chemical Review* states that recent analyses of the water from the Holy Well at Mecca, which is so eagerly drunk by pilgrims, shew this water to be sewage, about ten times stronger than the average London sewage.

Mode of Discovering the Adulteration of Honey.—20 parts of honey dissolved in 60 parts of water and mixed with alcohol, gives a white precipitate of dextrine if glucose has been added to the honey; if the honey is pure the liquor only becomes milky.

Domestication of the Edelweiss.—The edelweiss, that curious and interesting alpine plant so much desired by travelers in Switzerland has recently been grown by an English gardener in the midst of domestic vegetables. It behaves like a biennial. The search for it in Alpine districts has been so keen that in order to prevent its extermination, many cantons have thought it wise to prohibit its sale.

A New Kind of Rose.—In the publication of the Torrey Botanical Club, it is stated that three American botanists while riding through lower California, discovered a new rose which is apparently distinguished by botanical and horticultural peculiarities from the new and old world species. Dr. Engelmann has called it the "Rosa minutifolia" on account of the smallness and form of its petals. Seed-plots of it have been made.

Water filtration.—The use of spongy iron has now been applied on a large scale to the water obtained from the River Nette for the supply of the City of Antwerp Dr. Frankland has visited the Antwerp Water Works at Waelheim, about fifteen miles above that city, and reported on the results of his inquiry. He attaches especial value to the fact that spongy iron filtration "is absolutely fatal to bacteria and their germs," and he considers it would be "an invaluable boon to London if all water supplied from the Thames and Lea were submitted to this treatment in default of a new supply from unimpeachable sources."

Hygiene.—In the *Comptes Rendus* M. Burcq remarks that workmen who absorb in the form of fine dust, considerable quantities of copper are protected from cholera, save in instances quite as rare as those relating to the insufficiency of vaccine as a guard against small-pox, and that the same workmen seem to enjoy the same immunity with respect to infectious diseases, especially typhoid fever. M. Burcq proposes to employ salts of copper as an antiseptic for the planks of huts, infected ships, in the same manner as they are employed to protect the seeds of cereals and certain timbers employed in the industries, from insects.

The Watering of Plants in Pots.—Watering, says the *Neuste Erfindung*, is one of the most important considerations in the cultivation of plants in rooms and greenhouses. It must first be ascertained whether the plant really needs water and this can be done by striking the pot on the outside near the middle. If it gives out a clear ring the plant needs water; if the sound is dull there still remains enough of moisture.

Water is not required more than one or twice a day; in the morning in summer, in the evening in winter, but never when the sun is shining on the plant. Never use well water but either rain or running water.

MEDICINAL PROPERTIES OF WARM MILK.

Milk warmed (*not boiled*) to a moderate temperature is said to be a common remedy in India in cases of the most violent diarrhœa, stomach complaint, cholera and dysentery. According to the *Medical Times and Gazette* the employment of milk thus prepared is especially recommended for typhoid fever, and is the only food which nourishes the invalid and gives strength without unduly loading the stomach.

PROCEEDINGS OF SOCIETIES.

Montreal Microscopical Society.—Certain members of the old Microscopical Club met last month and organized a new Society, which held its first regular meeting on the evening of the 4th. The number of members is limited to thirty, and the meetings are to take place in the second Monday in each month. At the meeting on the 4th Dr. Osler read a paper on Parasitic bodies in the blood of the Frog, describing the Trypanosoma sanguinis of Grube and the Drepanidium ranarum of Lankester. Specimens of the latter were exhibited. Among interesting objects shown were the Filaria huminis sanguinis by Dr. Osler, Tubercle bacilli, prepared by Dr Wilkins, by Mr. W. B. Craig, and Prof. Bemrose exhibited a slide and called attention to the presence of bacteria in samples of pepsin.