RAILWAY BRAKES.

In a recent address before the Society of Arts, London, Mr. F. J. Bramwell said: Concerning brakes, they acted usually by arresting the wheel and causing it to act as a sledge. There were continuous brakes and brakes only applied to the tender and to the brake van occupied by the guard. If they converted a wheel when it was revolving into a sledge, the resistance was equal to one sixth part of the weight; if the tender weighed 18 tons, and its four wheels were converted into four sledges, there was a resistance of three tons. As to the time and distance, take a train weighing 160 tons, and going at the rate of 30 miles an hour. In that case it would have the velocity due to a fall of 30 feet. But the train of 160 tons travelling at the rate of 30 miles an hour would have a stored-up energy equal to 4800 foot tons. If they pulled that weight through one foot it would represent the energy of that train. So, by increasing the resistance, they decreased the distance the train would travel. It was, therefore, plain that they could calculate the distance within which a train could be brought to rest. That distance would vary with the square of the velocity. In a train such as he had instanced, weighing 160 tons, the tender and two guards' vans would weigh 42 tons. When the wheels were converted into brakes they would act with a force of $\frac{1}{6}$ of that, or 7 tons. If the train, therefore, were going at 30 miles an hour, it would bring it to rest in 230 yards. In practice, brakes could not be put on the moment they are wanted, and required double the distance given by the calculation. It might have been thought that much could be done by the reversal of the engines. They would see that the brakes on the tender and the two guards' vans had a resistance of 7 tons, while the tractive force of the engine was $1\frac{1}{2}$ tons. By reversing the engine, they only converted 7 into $8\frac{1}{2}$ tons, and the reversal of the engine was by no means a judicious mode of aiding the brakes. The reversal of the engine was an excellent way of working a train down an incline, or when they wanted some brake power for doing the work at stations. M. Le Chatelier, who died some two years ago, was the inventor of the *contre-vapeur* system. In it a small jet of water was injected into the cylinders, and was there converted into steam by the heat arising from the momentum of the train thus suddenly stopped. The heat was thus absorbed instead of being allowed to affect the cylinders injuriously. The ordinary way of working was by the two break vans, but there had recently been a great demand for the continuous self-acting brake, and some very careful experiments had been made. A late friend of his, a past president of the Institute of Civil Engineers, used to relate that inventors came to him and said they had a brake which would stop the train dead. "Then you have something to kill all the passengers," said he. But they might dismiss that risk from their minds. The best brake they had did not do much more than take $2\frac{1}{2}$ miles velocity out of a train in each second of time. See what velocity any person under the influence of gravity would obtain in each second of time. In a second of time a falling body would attain a speed equal to 30 miles an hour. They might fairly compare putting speed into the body and taking it out. A swing when in the middle of its course travelled at the rate of 30 miles an hour. Yet that was all taken out before it came up to the horizontal line, which would happen in $1\frac{1}{2}$ seconds. That 30 miles had been taken out at the rate of 17 miles in a second of time. Recollecting what the best brakes they had would do, they need not fear being killed by the shock. At a colliery near Wigan there were 806 yards of winding from the bottom to the top. They must stop perfectly accurately, or the cages would go over the drum above. In the middle of its course the speed was 58 miles an hour. They did not check that until they were within 180 yards of the top, so that they stopped that 58 miles an hour in that space without injury to any one. But if continuous brakes did enable them to be brought to rest in a very short time, they would become universal. They were by no means an unqualified good, for when the wheels were converted into sledges, flats were worn on them. That now only occurred, and of course caused jolting, in the brake vans, but if the brakes were made continuous, the same thing would happen all along the train as the wheels became subject to that kind of wear. Excessive brake power was not always useful in cases of accident. Sometimes it was productive of absolute harm. If a wheel of a carriage broke, and that carriage was coupled up tight with the carriage in front, so long as there was motion in the train and it was brought gradually to rest, no harm took place. But if continuous brake power were used, the train would be suddenly arrested, and the carriage no longer supported would cause an accident. Continuous brakes, in fact, would be an unalloyed good, if the engine driver had time to think of what was best to be done, or if he always knew what was best. That was not possible; but, on the balance of evils, Mr. Bramwell believed continuous brakes were a benefit. On some railways the express trains were provided with them, and he believed at the first station from London they stopped the train by means of them, to see that they were in order. But after that they used the ordinary brake, except in cases of accident, or to avoid collision. He would mention a matter that caused him extreme surprise—the height which Capt. Shaw told him London firemen were in the habit of jumping. Any of his men, he said, could jump 20 feet, and some jumped 30. But it made a great difference upon what body the impact was made. If a man fell on the pavement he broke his arm, but on a carpet he did not do so. Yet the thickness of the carpet was very slight. In the same way at rinks one heard of broken limbs, but there were few such accidents on the ice, because in the latter there was a slight elasticity.

TAKING UP WATER WITHOUT STOPPING.

MR. BRAMWELL described, by aid of a diagram, how a pipe let down from the tender dipped into a trough in which was from four to five inches of water. The mouth of the pipe scooped up the water, and a velocity of 16 feet would send the water up the pipe, and would fill the tender. The difficulty as to the proper place for lowering and raising the pipe was met by giving the rails for a few yards before arriving at the trough a slight rise, the top of the hill being reached opposite to the end of the trough. That carried the pipe over the end of the trough, and the engine going down a corresponding hill immersed the orifice in the water. At the further end of the trough the hill was repeated in the rails, and the pipe was carried clear of the trough. An engine could thus take in 1500 gallons of water without stopping.

CENTENNIAL EXHIBITION.—The first calendar month of the Centennial Exhibition closed with the evening of the 9th June, and the attendance for that time just turned 1,000,000 visitors.

GUATTARI'S PNEUMATIC TELEGRAPH.

FOR local purposes and short distances, so as to connect different parts of buildings, factories, etc., the pneumatic or air-pressure telegraph has of late been successfully introduced. The pneumatic telegraph is operated by compressing a quantity of air in a rubber receptacle and forcing the same through their connecting pipes to act on a second distant receptacle that is held compressed when in a state of rest. The expansion of this second receptacle actuates a bell or other signalling apparatus. The apparatus is, however, not applicable to greater distances, as the volume of air in the communicating pipes is too large to be compressed with considerable power by the pressure exerted by the first receptacle, especially as such pipe connections can not be kept tight enough to prevent the escape of air. The Italian engineer Guattari has overcome in a simple and ingenious manner some of the difficulties of these telegraphs, by substituting, in place of a few powerful compressions, a quick succession of alternating compressions and dilatations, which produce, so to say, an oscillating motion of the air in the pipes. Our illustration shows his pneumatic telegraph at one side in elevation, and at the other side in section, with the interior arrangement. The air is set in motion by a bellows M, that is worked by a handle I, and a spiral spring. A cock V is set by a crank R so as to connect the pipe leading to the bellows either with receptacle or bulb D, or with receptacle E. The oscillatory motion of its air, produced by the working of the bellows, actuates either one or the other of the elastic receptacles, and produces either the working of a lever that sounds a bell G, or transmits, analogous to the motion of the armature in electro-magnetic telegraphs, the oscillating motion of E to a train of gear wheels that moves the hand F on a dial A according as the crank is set. The button B serves to return the hand to the starting point indicated by a cross, while the button G regulates a spring of the wheel train ac-

GUATTARI'S PNEUMATIC TELEGRAPH.

ording to the length of the pipe connection. The apparatus works reliably for distances from 100 to 1000 metres, and the inventor has built an apparatus that works successfully for the distance of several miles.

CLAMOND'S THERMO-ELECTRIC BATTERY.

By LATIMER CLARK, C. E.

THE latest form of pair employed by Clamond consists of an alloy of two parts of antimony and one of zinc, as the negative metal, and ordinary tinned sheet-iron as the positive element—the current flowing at the heated junction from the iron to the alloy. The alloy is in the form of a flat bar, broader in the middle than at the ends, and measuring 2 to 2½ inches in length, by ¾ths of an inch to 1 inch in thickness. The sheet-iron, after being stamped out, is fixed in a mould into which the melted alloy is poured; before the alloy has cooled the mould is opened and the bars are removed. The alloy melts at a temperature of 500° F., and expands considerably in cooling; the more frequently it is recast the more perfect does the mixture become, so that old piles can be reconverted with advantage. The alloy is very weak and brittle, and can be broken almost as easily as loaf sugar.

The bars are arranged in a radial manner round a temporary brass cylinder, a thin slip of mica being inserted between the tin lug and the alloy to prevent contact, except at the junction. The number of radial bars varies with the size of the pile: eight or ten are generally used. The bars are secured in their position by a cement formed of powdered asbestos and soluble glass, or solution of silicate of potash. As soon as one circle of bars is completed, a ring of dry asbestos is placed upon it, and over this another circle of elements is built, and so on until the whole pile is completed. The entire structure is consolidated by means of cast-iron frames placed at the top and bottom, and drawn together by screws or rods. The inner face of each element is protected from excessive heat by a tin strip, or cap of tin bent round it before it is imbedded in the cement; the projecting strips of tin from the opposite ends of each pair of elements are brought together and soldered with soft solder by means of the blow-pipe. The positive poles are always placed at the top.

The pile is heated by gas mixed with air, on the Bunsen arrangement—that is to say, the tube up which the gas passes is pierced with a number of small holes, and these approximately correspond in position, as well as number, with the elements employed. Through an orifice in the gas supply tube, a regulated proportion of air passes, and this mixes with the gas before entering the tube forming the chimney. Through the small holes the mixture escapes, and in the annular space between the tube and the elements, it burns in small blue jets, the products of combustion being carried off at the top. When combustion is going on properly, the

earthenware tube glows with a dull cherry-red color, and none of the jets should impinge on the elements. By means of an excess of gas, the pile may be overheated and the connections of the elements destroyed; when in good order, the temperature of the inner bars should be about 400° F., and that of the outer about 200° F.

To prevent, as far as possible, injury from overheating, and at the same time to lessen the consumption of gas, Clamond has recently introduced a new form of pile, from which he derives considerable advantages. The mixture of gas and air is still burnt as before in the earthenware tube; but this, in place of extending up the whole height of the battery, is carried up to only about half its height. The earthenware tube in the new arrangement is surrounded by an iron tube of greater diameter, which is carried up almost to the top of the battery, and is open at the top. The elements are placed in the usual way outside the iron tube, and from the bottom of the annular space intervening a chimney leads off. The top of the pile is covered over by a closely fitting movable cover. The air enters at the bottom of the iron tube, and the heated gases pass upwards to the top; finding no means of escape there, they curl over, and descending outside the iron tube—that is, between it and the elements—they finally make their exit by means of the chimney already referred to. The elements are thus heated partly by radiation from the iron tube and partly by the heated gases on their way downwards to the chimney. Not only is the danger arising from the gas jets impinging on the elements thus removed, but the consumption of gas is said to be reduced by one-half. Should a bad connection occur, it is short-circuited by a piece of wire, and a defective element can readily be cut and replaced by a sound one.

A small gas regulator (to keep the pressure of gas, as far as may be, constant) is employed with each machine. The consumption of gas in small-sized elements is stated to be about one foot per hour for each volt of tension. Where gas is not

available for heating purposes, coke or charcoal is found to answer very well. Paraffin oil might probably be employed with advantage, although thus far it does not seem to have been successfully used as a source of heat in the thermo-piles.

Iron screens are sometimes employed to surround the pile, their object being to cool the external surfaces of the elements by causing a current of cold air to pass over them. They likewise prevent, to some extent, the fracture of the bars which takes place if the pile cools too rapidly. The subject of screens and other mechanical appliances for cooling the external surfaces of the thermo-electric elements, such as currents of air, the use of water, evaporation of moist surfaces, etc., have thus far been imperfectly investigated, and throw open a wide field for research, notwithstanding the labors of M. Clamond.

The electro-motive force of a thermo-electric element, such as those employed in Clamond's pile, is such that twenty elements may practically be regarded as equivalent to one Daniell's cell in this respect—that is, they give about one volt.

They are made by the Thermo-Electric Generator Company, London, the sizes being 2 volt, or 40 bars, price \$15, up to 34 volt, or 680 bars, price \$160.

It is found that the electro-motive force of the several layers of elements varies, owing to the fact that some are more fully exposed to the heat than others. The middle layers seem to give the best results, although when first heated the upper bars are stated to give the greater electro-motive force.

So extremely sensitive are the thermo-electric piles, that it is all but impossible to find one in such a state of equilibrium as to give no evidence of a current. If it be so, the passing of the hand into the interior of it, breathing upon it, or even the approach of the body, immediately sets up an action; and whilst they are at work, the effect of a distant fire, or the opening of a window, will produce a sensible effect upon them. When two or more piles, therefore, are employed, they should, in order to secure the best working, be kept as far apart as possible, and allowed free radiation.

Electro-deposition is one of the many uses to which thermo-electric piles may be turned, and they are already largely employed for electro-plating. As an instance of what has been done, a battery of 375 elements (whose internal resistance was 4.5 ohms, and electro-motive force 14.6 volts) deposited about 180 grains of copper per hour, but then the electro-motive force was sufficient to have created a similar deposit in several successive cells, so that no practical results have yet been made known which could be accepted as a theoretical possibility of the work to be effected by them in this respect.

The mechanical power obtained from thermo-piles by electro-magnetic engines has not yet been put to any practical use, nor can it be looked for as ever likely to be worked from

an economical point of view. The electric light furnished by them is powerful and constant, but a very large number of elements has to be employed in order to secure this.

For laboratory use they are very handy, and by utilizing the waste heat of kitchen fires they might doubtless be employed to considerable advantage for domestic purposes.

LIGHTNING CONDUCTORS.

M. R. F. MICHEL has lately made two interesting communications on the subject of lightning conductors to the Académie des Sciences, Paris.

For some years the use of copper wire ropes has been recommended for this purpose, this metal being a much better conductor of electricity than iron, and the ropes formed from it lending themselves readily to the architectural contours to which they might be attached. But, besides the fact that the high value of the metal affords too great a temptation to the cupidity of the workman, the ropes themselves frequently undergo considerable deterioration under the action of the electrical currents passing along them, of the atmosphere, and of the vibrations to which they are exposed; the copper becomes crystallized and brittle, the wires snap one after the other, and the consequence is that in a short time the available sectional area of the rope is considerably reduced.

The author also calls attention to the very defective method of manufacturing these cables, whether of copper or of iron. When it is desired to join a wire accidentally broken, or of insufficient length, the two ends are merely twisted together, without any precaution being taken to secure the proper contact at the joint. Oxidation ensues, and it may happen that the conductive power of the rope is materially lessened, and even completely destroyed. The conductor should, therefore, be formed of iron rods welded together, or of a rope consisting of large wires with no joints; plates of copper, however, seem to possess considerable advantages for this purpose, without any of the drawbacks mentioned. The Paris Bourse has a ridge cover of copper connected with the lightning conductors, which was put up a long time ago, but is still in a perfect state of preservation and electrical conductivity, as proved by some recent delicate tests.

In the second communication the author states that for the last year he has undertaken a microscopical examination of the points of lightning conductors, and has also subjected them to chemical analysis. The result has been that about 40 per cent of the points examined were found to contain from 6 to 17 per cent of lead. Some points, even of small dimensions, had been hollowed out inside, so as to leave a shell of only 0.75 of a millimetre thick, and into the cavity thus made a composition of equal parts of lead and tin had been run. After cutting one of these points, and placing it in a crucible raised to a dark-red heat, the fusion of the composition left an empty space, and in some of the platinum points the composition adhered so slightly as to be easily removed by the aid of a punch.

At the time of the inquiry into the state of the lightning conductors surmounting the municipal buildings, M. Michel found that the proportion of platinum points bent, burnt, or fallen off, amounted to 80 per cent, and he has come to the conclusion that it is quite impossible to verify the state of the platinum points of lightning conductors.

SHOOTING STARS.

By Prof. C. A. YOUNG.

THEY are very small, for the most part, as Newcombe and Harkness have shown, weighing certainly not more than a few grains, and possibly only some thousandths of a grain, mere particles or cloudlets of dust, which are travelling in space under the same laws as those which govern the motions of the planets and comets, and with a velocity as great; varying in different cases from 8 or 10 miles per second to 40. The least velocity named is more than thirty times that of a cannon-ball. When they encounter our atmosphere this velocity is destroyed by the resistance, and according to well-known laws, their energy of motion is converted into heat of intensity sufficient to render them incandescent, and even to dissipate any solid portions in vapor.

It is the amount of light they give which furnishes the evidence as to their minuteness, but it would take too long to show just how the conclusion is arrived at.

Their numbers are very great. It is found that one observer will on the average see from 4 to 6 per hour at any given place, and careful experiment shows that a single person sees about $\frac{1}{2}$ of all that could be seen by a sufficient number of observers so placed as to watch minutely every portion of the sky. About 40 per hour is therefore a fair average for one station, or nearly a thousand each day. If the calculation is carried out for the whole earth, allowing that at each station all are observed which come within a circle 200 miles in diameter, we find the total number that reach the earth daily is about 5 millions; indeed, Professor Newcombe, who is perhaps the highest authority on this subject, sets the number still higher, at 7 $\frac{1}{2}$ millions. A curious fact is that the hourly numbers increase from sunset to sunrise by some 50 per cent. The reason is simply that in the evening we are, so to speak, behind the earth as it rushes through space, and see only those which overtake us; in the morning, on the other hand, we are in front, and see all we meet, as well as those we overtake.

Of course, if meteors are thus perpetually entering the atmosphere, it is natural to ask, What becomes of them? Do they reach the earth? Probably, as impalpable dust. Nordenskiöld, during the recent arctic expedition, examined with great care quantities of snow from regions apparently beyond the reach of all human adulteration, and on melting the snow and evaporating the water he always found a residue consisting largely of iron and its oxides. This he considers to be of meteoric origin, and it is not improbable, considering how important a constituent iron is found to be in those larger masses, the aërolites, which from time to time fall upon the earth and are collected into our cabinets. —*Boston Journal of Chemistry.*

THE SATELLITE OF VENUS.*

AN indirect result of the recent Transit of Venus has been the revival of a nearly forgotten but not uninteresting speculation as to the possible existence of a satellite accompanying her. Nothing of the kind was observed on the late occasion, but the planet's path was so far from central that an attendant might readily have remained outside the solar disc; and therefore, though the negative evidence, if it had required additional strength, would have received it from this non-appearance, it would not have been rendered absolutely con-

clusive on that ground alone; and, so far as the Transit is concerned, there is still room for an essay like that before us, which, previous in composition though subsequently published, advocates the affirmative opinion. That opinion, after so many years of additional observation since Lambert's memoir in 1777, is not likely to find favor with astronomers now, and certainly will not be established by the present treatise. It is an unpleasant task to express any other than a favorable estimate of any work undertaken with a view to enlarge the boundary of knowledge; but in the present instance it is unavoidable. There is, indeed, a very considerable accumulation of historical matter, and there are some pleasant anecdotes, and a few valuable and little known facts; but the materials of some portions at least are neither complete nor accurate; the premission of recent discoveries—especially spectroscopic—is sometimes simply unaccountable; and the hypotheses occasionally partake of an extravagance that outstrips all probability. The subject is, however, as has been remarked, not devoid of some interest, nor, to say the truth, disentangled from some perplexity of an obstinate character; and it is worthy of a more satisfactory elucidation, which might be comprised in a narrow compass, as its literature is not extensive. A few remarks only can be attempted here.

That something strongly resembling a satellite has been occasionally seen near Venus, especially about the middle of the last century, is beyond a doubt. It is equally certain, and familiar to all experienced observers, that reflected images, or technically "ghosts," may, under certain circumstances, be formed in the eye-piece of the telescope, and might be the means of causing deception: and the whole matter is reduced to the simple inquiry, whether all the recorded instances admit of this easy explanation; though, if they do not, it must be remembered that the existence of a satellite would not necessarily follow.

Abbot Hell, who published an elaborate dissertation on the subject in the appendix to the Vienna Astronomical Ephemerides for 1766, seems to have been the first to study systematically the formation of telescopic ghosts. The Vienna Observatory was possessed in those days of two good English telescopes, left to it in 1757 by Cardinal de Trautson; a 2 ft. Gregorian, and a 4 $\frac{1}{2}$ ft. Newtonian. About December in that year, the abbot, examining Venus with the former instrument and a power of 70 or 80, perceived a star of an ill-defined aspect near it like a little comet, but as it was invisible both in that Newtonian and in another of the same construction of 4 ft., he referred it to a reflection from the interior of the tube. In March, 1758, Venus being at her greatest elongation, the illusion returned, on which he blackened the tube, and for some days did not see it again; but when at length it reappeared, on moving his eye very gently towards the eye-piece he found it change into a perfect image of a satellite with the phase of the primary. Beyond the limit of barely half a line either way from this position, it was invisible. When Venus occupied the centre of the field, this "spectrum," as he calls it, was near the edge; as he moved his eye round, or up and down, the image moved the same way, generally disappearing in the neighborhood of the planet. A set of experiments instituted in consequence satisfied him that this image was formed by rays reflected first from the convexity of the "pupil" (cornea), and a second time from the concave face of the meniscus lens which in this case formed the eye-glass, though it would be shown by any eye-piece possessing a surface concave towards the retina. Cases were even possible, but difficult in management, when an image might be seen, though the object was not in the field; but this was formed by rays passing outside the telescope, and the ghost would be inverted and of much smaller dimensions. The magnitude of the image would depend on the proportion of curvature of the reflecting surfaces. This being once understood, the Abbot found that he could always produce, for himself or others, a spurious satellite of Venus, or Mars, or Jupiter, under the following essential conditions: That the power should not be less than 50 or 80, or the image would be too minute to be visible, or would only resemble a small star; that the eye must be placed at a definite distance from the eye-glass, and be moved most deliberately and cautiously backwards and forwards to find that point, the limit of visibility being sometimes only a quarter of a line either way; and that the eye must be a little on one side of the optical axis, or the image will coincide with its primary. And it becomes readily intelligible why an observer, ignorant of these conditions, may never be able to recover an image which he had once accidentally seen. Thus far, in substance, the astronomer of Vienna, who certainly deserves credit for his ingenious and careful investigation. His reasoning is, nevertheless, a curious and instructive exemplification of the way in which a preconceived opinion may block up the mental view, and prevent a sound argument from being carried out to its legitimate consequences.—*Nature.*

A NEW DOUBLE-REFLECTING TELEMETER.

TELEMETRY, or the art of determining rapidly and accurately distances on the earth's surface, apart from its numerous economic applications has become absolutely indispensable in the use of modern weapons of war. Various mechanical devices for these purposes have been invented, but none hitherto similar to that illustrated, devised by Lieutenant Gaumet, French army, which is adapted for carriage in the pocket. A perspective view of the instrument is given in Fig. 1. Fig. 2 shows the interior. Two mirrors are disposed on a metallic plate so that an angle of 45° is made between them. One mirror is fixed; the other is mounted on a movable alidade, so that the above angle can be varied from 41° to 49°. A micrometric screw of .04 inch travel per turn has a disk on its head, which is divided circumferentially into

FIG. 1.

100 parts. This screw moves in double nuts on the metallic plate. The disk travels in front of a divided rule, each division of which equals .04 inch. A spring causes constant contact between the arm of the alidade and the extremity of the micrometric screw.

All the above parts are contained in a rectangular box, as shown in Fig. 1, having at its rear an opening for the eye, and on the right side a similar aperture through which the rays pass to the mirrors. The principle on which the device is constructed is a simple application of that of double reflec-

tion. When a luminous ray is reflected successively by two mirrors placed in a plane perpendicular to the intersection of the mirrors, the angle formed by the incident and the reflected ray is double the angle of the mirrors.

In order to measure a distance by the instrument three operations are necessary. These will be understood from Fig. 3, and are as follows: 1, to determine the right angle C A M; 2, measure a base A B; 3, measure an angle at A C B, A C being the distance to be determined. The observer posts himself at A, the point C being on his right. The re-

FIG. 2.

flected image of this point then appears directly above the direct image of the fixed station M, which is regarded in direction perpendicular to A C. (The angle C A M is right whenever the two mirrors make an angle of 45°.) The observer now, by means of a tape provided with the instrument, measures off a distance along the line A M of A B = 60 feet. He then proceeds to B and regards anew the signal point M, between which and C there will no longer be a coincidence, the latter appearing to the right, say at C'. To re-establish the coincidence the movable mirror is turned to an angle equal to $\frac{1}{2}$ C' B M, which equals $\frac{1}{2}$ A C B. The angle of rotation of the mirror is in the instrument measured by its tangent by the aid of the micrometric screw. This gives a very close approximation. When the coincidence above referred to is obtained the number of turns made by the screw is read from the scale, and this equals the measure of the tangent of the angle of rotation of the mirror. This angle of rotation is half the angle A C B. The relation, therefore, between the distance from the pivot of the movable mirror to the axis of the micrometric screw and double the

FIG. 3.

number of divisions equals the ratio between the unknown distance and the base measure. Therefore, D being the distance to measure; b the base taken, say 60 ft.; l the distance of the pivot as above, which in the instrument is 2.2 inches, and n the number of divisions, we have

$$\frac{D}{b} = \frac{l}{2.2n} \quad \text{or} \quad D = \frac{2.2}{n} \cdot \frac{b}{2.2}$$

Whence we obtain for each instrument a constant which, divided by the number on the scale, at once gives the distance sought. On every instrument a table prepared from the above formula is fixed so that the observer merely has to glance thereat to determine the distance without calculation.

This invention is in principle the same as that patented in the United States, March 16, 1875, by Mr. William F. Hausch, of Chicago, Ill.

HOW PLANTS FEED.

DR. SACHS recently delivered a lecture on this question before the Frankischen Gartenbau-Verein, in which he reviewed the present state of our knowledge as enriched by the latest investigations. The following is mainly the substance of the lecture, as abstracted from the *Gardeners' Chronicle*. It contains, as a matter of course, many well-known facts, but they are put together in a form that will be welcome to those who have not time to cull them out of scientific books. With regard to successive periods of nutrition and growth, we have only to mention bulbous plants, germinating seeds, and the unfolding of the buds of trees in spring. It is true that water, which is necessary for the enlargement of the organs, is taken up, but there is essentially no storing up of food at this period; on the contrary, there is a consumption and exhaustion of the nutritive substances previously accumulated in the plant. The fact that this process is perfectly effected with distilled water is accepted as a proof of this assumption. The enlargement of the growing parts is effected solely by the absorption of water, and therefore the whole operation is essentially one of a change of the "reserve substances" already present. On the other hand, the horse chestnut, walnut, and other trees, present us with examples in which the conditions are reversed during the summer months. The formation of branches and leaves ceases, and large quantities of nutritive substances are stored up in the tree, and not appropriated till the following spring. Again, there are many plants, especially those of annual duration, which grow during the night when nutrition is not proceeding, and in which both operations are carried on simultaneously during the day. In these cases it is in the roots and fully developed leaves that the process of nutrition is going on, and growth in the buds, flowers, and fruit.

With regard to the sources of the food of plants it has been proved by direct experiment that they receive by far the greater part of it from the atmosphere through their green leaves. The small quantity of ash that remains after burning a plant, together with a large proportion of the water contained in the plant, represents what is taken in by the roots from the soil. This ash consists chiefly of alkalies, lime, magnesia, of phosphoric acid, sulphuric acid, chlorine, and silicon, mixed with a

* "Der Venusmond," etc., von Dr. F. Schorr. Braunschweig, 1875, pp. 186. T. W. Webb.