supported, is introduced into the hollow central part of the mould, the molten glass being prevented by a button from entering the latter. The lip of the bottle is shaped first, and the mould is then quickly reversed, causing the molten glass to fall down by its own weight. When the mass has descended to the length required, the halves of the mould are closed on it, a current of air from the pump is turned on, and the bottle quickly blown into the shape of the mould. A different mould is, of course, required for each kind of bottle.

The principal improvement which it is proposed to introduce into the machine now at work is to fix a number of machines—say four, six, or more—on a revolving stand, turning round as quickly as possible, one man being continually employed filling the moulds with the glass metal, another working the air pump and closing the moulds, and a third taking out the finished bottles.

The first result of the introduction of the perfected machines will be to diminish the number of hands employed; but as a large increase of orders is anticipated, owing to the impossibility of foreign competition, which now supplies this country with about 16,000 gross of bottles per day, or two and a half times as much as we ourselves manufacture, it is thought that the growth of business will quickly necessitate the employment of even a larger number of hands than are now engaged.

The inventor of the machine claims that the producing capacity of Messrs. Sykes, Macvay & Co.'s works, if sixty machines were set at work (one for each "hole" now existing), would be increased tenfold, or from 5,400 to 54,000 dozen bottles per day, while, instead of 300, only 180 hands would be required, and the cost of labor would be reduced from 3s. 10d. to 3d. per gross.

The exploiters of the patent propose to allow other firms to use the machine upon payment of a royalty, but all the machines will be made at the Sykes-Macvay works, and duly numbered and registered.

Mr. Ashley's partner in the patent, in the course of conversation, told our representative that, when they first asked permission from bottle manufacturers to put the invention to a practical test, they were everywhere received with suspicion, and found all works closed against them. As it was impossible to obtain a proper supply of molten glass without the employment of expensive fireclay pots, the erection of ovens and other preliminaries involving a heavy expenditure, it was resolved to use a mixture of molten shellac and resin instead of the glass metal. The inventor then constructed an improvised machine in an empty blacksmith's shop, and there succeeded in manufacturing excellent bottles from the shellac and resin mixture. These were shown to Messrs. Sykes, Macvay & Co., who thereupon decided to take the matter up.

THE POLAR PLANIMETER—ITS THEORY AND ITS USE.*

By E. A. GIESELER, C.E.

BY means of this instrument the area of any regular or irregular plane figure can be found by running the tracer once around the circumference of it. In the following the writer has attempted to give the theory of this useful device in a more simple way than it is generally given.

The instrument consists of a system of two bars, FI and IT, rotating around the fixed fulcrum, F; see Fig. 1.

One of them, IF, which we will designate as the *polar arm*, is jointed at I to a sleeve, in which slides the other bar. In a parallel position to such sleeve, and attached to it, there is an axle revolving in bearings and carrying a small wheel, W. The bar, IT, which we will designate as the *movable arm*, can be shifted and clamped in any desired position in the sleeve; the distance from the tracer, T, which this arm carries at its extreme end for the purpose of following the lines of the drawing, to the joint, I, is therefore variable, and on its setting depends the value of the unit in which are expressed the results obtained by the instrument.

When the apparatus is put up for use, it rests on the plane of the drawing with three points, viz., the tracer, T, one point of the circumference of the wheel, W, and the fulcrum or pole, F, which latter consists of a ball joint held in place by a heavy weight, and around which the system of bars freely rotates. It is at once clear that with the tracer of this instrument the contour of any area can be circumscribed, provided that the size of the same does not exceed the limit of the apparatus, and further, that the position of the fulcrum has been properly chosen. This can be selected either *inside* or *outside* of the figure the area of which is to be found, both of which cases must be considered separately.

1. *When the fulcrum is outside of the area.*—In Figs. 2 and 3, A represents the figure the area of which is to be found; the instrument, with its fulcrum *outside*, is shown in various positions, the sleeve carrying the wheel having been left out so as not to unnecessarily complicate the diagrams.

Let us suppose the starting point of the tracer to be at the extreme left of the area, so that on being started on its path around it, in the direction of the arrow, its new positions will be to the right of the extended line IT.

Now the journey of the tracer around the entire contour may be considered as consisting of two distinct parts. *First*, the part in which the tracer travels from its first, the above described extreme left position, along the upper part of the contour until it arrives at the extreme right position, from which any further movement will bring it to the left of the then position, T¹ I¹, of the movable arm. *Secondly*, that part in which the tracer travels from the extreme right position along the lower part of the contour until it arrives once more at the starting point. The first part of the tracer's journey is represented in Fig. 2, the second part in Fig. 3; in both diagrams two intermediate positions of

the instrument being shown, which, in distinction to the heavy lines of the extreme positions, are drawn in light lines.

In order now to investigate what takes place during the first part, represented in Fig. 2, we will consider the movement of the arm from the intermediate position, T¹ I¹, into an immediately adjoining one, T² I². This movement can be resolved into two components, viz., a progressive one, the direction of which is perpendicular to the arm and by means of which it arrives at the dotted position parallel to T¹ I¹, and a rotating one, by means of which it is turned from such dotted position into the actual new position, T² I². If now we assume that both these movements always take place in the

direction of the arrow, and that during the entire voyage of the arm from one extreme position into the other extreme position there is never a retrograde movement in the opposite direction, then we perceive that the shaded area in Fig. 2 can be expressed as the sum of the small parallelograms and sectors into which each space inclosed between two successive positions can be resolved. When it is further considered that the first movement of the arm, during which the space of the parallelogram is covered, is at right angles to it, then it appears clear that during such movement the wheel must roll off an arc, the length, r , of which is equal to the height of such parallelogram, the area of which latter is therefore equal to $M \times r$, M being the length of the movable arm. We have accordingly:

Shaded area Fig. 2 = $M \times$ sum of the various r + sum of the various sectors.

The same line of argument will lead to a similar equation for the shaded area in Fig. 3, and as the difference between these two shaded areas is equal to the area inclosed by the curve, we obtain an expression for this latter by subtracting the second equation from the first one. This expression will be made up of two terms, one containing the parallelograms and the other containing the sectors.

In regard to the last term, it is clear that the sum of the sectors in Fig. 2 must be equal to the sum of the sectors in Fig. 3, the movable arm having made the same number of rotatory motions in each case; the sectors therefore annul each other. It is equally clear that the length rolled off by the wheel during the rotatory movements must be the same in both cases, the sum of the various sector angles being the same in Fig. 2 as in Fig. 3, and as their lengths are rolled off in opposite directions, they will also annul each other; or in other words, if it were only for the motions made while covering the sectors, the wheel at the end of its journey would be found not to have rolled off any length whatever.

The term containing the sectors annulling itself, the expression for the area inclosed by the curve is now reduced to the term containing the parallelograms, that is—

$$\text{Area} = M \left\{ \begin{array}{l} \text{sum of the various } r, \text{ Fig. 2—} \\ \text{sum of the various } r, \text{ Fig. 3 } \end{array} \right\}$$

As the sectors do not cause any length at all to be rolled off by the wheel, the difference in the brackets is

clearly equal to the entire amount which the wheel will be found to have rolled off on its return to the original position, and designating this amount with R , we now have the simple equation—

$$(1) \dots \dots \dots \text{Area} = M R.$$

That is, the area inclosed by the curve is equal to the area of a rectangle with the length of the movable arm as a base and the length rolled off by the circumference of the wheel as its height.

In the above deduction the shape of the curve has been assumed to be such that the progressive motion of the movable arm from the left to the right in Fig. 2, and from the right to the left in Fig. 3, is never interrupted by any temporary retrograde movement, at any of the intermediate positions. This state of affairs, however, very rarely obtains in reality. The various positions of the movable arm will, on the contrary, cross and recross each other frequently, and the arm will often change the direction of its motion. But it is easy to prove that these complications do not alter the result of our deductions in the least.

In each case of a retrograde movement of the movable arm, a portion of the wheel record will be annulled, such portion representing a certain portion of the shaded area in either Fig. 2 or Fig. 3, according to whether the retrograde movement takes place in the first or in the second part of the journey. But it is clear that the movable arm will eventually have to pass over precisely the same area again, thus restoring the annulled portion of the wheel record. All retrograde movements will, therefore, cause certain amounts to be added to, and precisely the same amounts to be subtracted from the shaded areas, as well as the wheel record. The final result therefore remains unaffected for both.

2. *When the fulcrum is inside of the area.*—In this case the end, I, of the polar arm will describe a full circle instead of an arc, as in the first case. Suppose now that this circle is inclosed entirely by the curve itself, as shown in Fig. 4, then it is clear that the

difference in area between the two (which difference is shaded in Fig. 4) must be equal to the sum of the various parallelograms plus the sum of the various sectors described by the movable arm, during the entire journey. As far as the sectors are concerned, nothing is changed if we imagine the end, I, of the movable arm to have remained stationary during the occurrence of the various rotating movements, which carried the arm from its first position through an entire circuit around I as a center, back again to such first position. We perceive from this argument that the sum of the various sectors is equal to the area of a circle described with the movable arm as a radius, that is,

$$\text{Sum of various sectors} = M^2 \pi.$$

During this portion of the movement the wheel will roll off a length equal to the circumference of a circle the radius of which is its distance from I; and designating this with l , we have—

$$\text{Wheel record corresponding to sectors} = 2 l \pi.$$

The remaining part of the wheel record, according to our previous deductions, must be the sum of the heights of the various small parallelograms.

Designating as before the entire wheel record with R , we therefore obtain—

$$\text{Sum of heights of parallelograms as given by wheel record} = R - 2 l \pi.$$

And further—

$$\text{Sum of the various parallelograms} = M (R - 2 l \pi).$$

The sum of the various parallelograms plus the sum of the various sectors renders the contents of the shaded area, consequently—

$$\text{Shaded area Fig. 4} = M (R - 2 l \pi) + M^2 \pi.$$

And adding to this the contents of the circle described with the polar arm, P, as a radius, we clearly obtain the entire area inclosed by the curve—

$$\text{Entire area} = M^2 \pi + P^2 \pi + M (R - 2 l \pi) \quad \text{or}$$

$$(2) \quad \text{Entire area} = M R + \pi (M^2 + P^2 - 2 M l)$$

The second term on the right side of this equation is a constant for each setting of the movable arm, the other two values, P and l , always remaining the same. The area is therefore found to be equal to a rectangle with the length of the movable arm as a base and the length rolled off by the circumference of the wheel as its height plus a certain constant.

The circumstances are not materially altered when the circle described by the movable arm is not inclosed entirely by the curve, as shown in Fig. 5. The difference between their areas in this case is equal to the difference between the two shaded areas, A and B, and this latter difference is equal to the arithmetical sum of the various parallelograms and the various sectors; this will appear quite clear when it is remembered that aside from temporary retrograde movements, A will be covered by the movable arm advancing and the wheel rolling in a direction opposite to both mo-

* Copyrighted.

tions while covering B. The difference of the area of the circle and the area of the curve will therefore be in this case, as before, equal to the arithmetical sum of the various parallelograms and the various sectors, the rest of the deduction remaining precisely the same as in the foregoing case.

For practical use it is desirable that with the fulcrum *outside* of the area the wheel record should render the latter direct, without the multiplication with the length of the movable arm being required. This can be done by a proper adaptation of such length as follows.

Suppose, for instance, the diameter of the wheel to be $\frac{3}{4}$, then the wheel record for n revolutions is

$$R = n \frac{3}{4} \pi = 2.356 n$$

and by substituting this into equation (1) we find:

$$\text{Area} = 2.356 M n$$

In order now to let n indicate the result directly, all that is required is to make the product $2.356 M$ equal to either 1 or 10 or any other power of 10. Suppose we assume

$$2.356 M = 10, \text{ then we have } M = \frac{10}{2.356} = 4.2$$

That is, when the length of the movable arm is made $4\frac{1}{2}$ inches, then each revolution of the wheel will indicate an area of 10 square inches. The circumference of the wheel is graduated into 100 parts, and by means of a vernier the one thousandth part of one revolution can be read, so that in the case of the setting discussed just now, each vernier unit would correspond to the hundredth part of a square inch. A small horizontal disk, connected with the axle of the wheel by means of a worm, keeps a record of the number of revolutions up to ten. The reading to be taken at the commencement of a measurement therefore consists of four figures, viz., the disk figure, the tenths and the hundredths of the wheel circumference, which are read on it direct, and the thousandths, which are read by means of the vernier. Suppose that with the fulcrum outside of the area and with the above setting of the movable arm, the reading at the commencement of a measurement was 4269, and that the reading taken after the tracer had traveled around the entire contour was 5374, then the difference between the two readings is 1105, which shows the area to be 11.05 square inches.

It is indifferent in which direction the tracer is taken around the contour; if taken as the hand of the watch travels, then the first reading has to be deducted from the second, and *vice versa*.

In practice the above described method of obtaining the setting of the instrument, besides being too time-robbing, is open to the objection that the requisite measurements cannot ordinarily be made with sufficient accuracy. The planimeters sold by the firm of Keuffel & Esser, of this city, are each accompanied by a table giving a limited number of settings, the figures of which table correspond to a graduation engraved on the movable arm. Any settings not contained in this table are found by trial, for which purpose a trial figure is furnished, the grooved rim of which incloses a known area and around which the tracer can be carried with exactitude.

The constant for inside positions of the fulcrum is found by measuring with an inside position a regular figure such as a square or a circle, the contents of which can easily be found by computation. The difference between the actual contents and the contents as given by the planimeter, or more precisely the difference between the wheel record with the fulcrum outside and that with the fulcrum inside, will be the constant. Care must be taken to note whether the wheel record in the second case is positive or negative. If the latter, then the constant will of course be larger than either area or wheel record.

IMPROVED PRIMARY BATTERY.

By P. SELBY.

AMONG other things brought out here (Sydney, New South Wales) by me nearly four years ago was an *electric pen* apparatus with a Fuller bichromate battery. The difficulty of obtaining suitable cells and zincs for replacement caused me to seek some other form of cell by which the expense and internal resistance of porous pots could be avoided. After sundry experiments with a view to narrow the matter down, I arrived at a stoneware jar containing the usual bichromate potass solution plus sulphuric acid, a piece of thin platinum wire clothed with pure black India rubber, and a $\frac{1}{8}$ inch tube cemented to the wire at an inch from the bottom. The spare inch of wire was then made into a flat spiral capable of picking up a small quantity of mercury (Fig. 1), the India rubber tube being simply for insulation, so that the platinum should not affect the result. On plunging this into the jar of solution a good current was produced for a short time; when withdrawn for examination, it was found that *part* of the mercury still adhered to the platinum wire, although action had ceased; a fresh dip of mer-

cury restored the effect. On investigation I found that the mercury had been used with zinc, and was in fact *an amalgam*. The absence of zinc meant absence of effect. On this result a simple and effective cell was formed. (Fig. 2.) A small jar (2 oz. Liebig's extract of meat jar) was divided off by a *glass partition* cemented

FIG. 1.

FIG. 2.

FIG. 3.

in with bicycle tire cement (more expensive than Chatterton's, but much stronger for grooveless partitions, jointing parchment paper cells for Leclanchés, India rubber, gutta percha, shellac, and bitumen) reaching *nearly* to the bottom of jar; mercury is then poured in (dotted in Fig.) to form a "sealed joint" to separate the fluids; carbon on the one side of the partition (but *suspended* so as not to touch the surface of the mercury) in bichromate potass, sulphuric acid solution, and on the other side zinc standing in the mercury in *plain water* to assist in counterbalancing the bichromate fluid on the other side, so as to require less mercury to make a safe joint. Of course the jar is represented wider than is really the case, so as to prevent confusion in the sketch. I was led to this form by many circumstances, among others the peculiar way in which a zinc in bichromate battery was "undermined" where it was outwardly protected by a cement which resisted the action of the dilute acid solution in the porous pot.

For cheapness and handiness, glass tumblers or drinking glasses with what are known as *well bottoms* (Fig. 3) would make up very handy cells for experimental purposes.

Further experiments led to a "thistle tube" of glass arrangement, the tube (Fig. 4) being bent in a gas

FIG. 4.

FIG. 5.

FIG. 6.

flame as shown, mercury placed therein, and copper wire being passed down the stem into the mercury. This is simply placed in a jar of solution containing the carbon, but the mercury must receive occasional replenishments of small pieces of sheet zinc, which readily dissolve in it. The thistle tube is convenient for lifting in and out, and when it can be lashed to a spring clothes peg clipped on the top of the jar.

But for permanent use a small shallow pot of earthenware (such as Needham's metal polish is sold in—Fig. 5) has a round zinc rod cemented in firmly, so as to

form a means of lifting in a complete state out of the outer battery jar, mercury is then poured in to form a "water joint," a paraffin lamp chimney with a "crinkled" top (Fig. 6) is then inverted and passed down the zinc rod into the mercury and filled with *pure water* to counterbalance the pressure of the *surrounding* fluid (bichr. potass + ac. sulph., usual solution), in which stands the carbon.

Note.—This water remains purely free from any acidity for months, and by careful tests I find that the addition of sulphuric acid simply weakens the battery by setting up a "counter" current. In the "porous pot form" the acid seems quite necessary to lower the

resistance of the fluid, but here it is different. Of course a preferable form to avoid risk of cement giving way would be to make the glass and the dish in one (in glass), with piercings to insure the continuity of the body of mercury in contact with the zinc and the bichrom. ac. fluid.

The thistle tube arrangement I do not like, owing to having to supply the zinc, and the surface of mercury is too small, too, but the other arrangements I have tested for six months successfully.—*Elec. Review*.

[Concluded from SUPPLEMENT, No. 636, page 10160.]

THE POSITION AND PROSPECTS OF ELECTRICITY AS APPLIED TO ENGINEERING.*

By WILLIAM GEIPEL.

III.—ELECTRIC LIGHTING.

OF the four branches of electric engineering dealt with in this paper, electric lighting is the one which up to the present has received most attention, called forth the largest outlay of capital, and produced the most beneficial results, if not to so great extent in this as in other countries. Artificial illumination may be considered in the three aspects of comfort, convenience, and economy. As regards comfort, electric lighting proves itself superior to all other methods of illumination. For indoor lighting, the incandescent light may be utilized and toned down to suit almost any requirement. It may be brought near to any object requiring illumination, without occasioning the least inconvenience from heat or dazzle, or it may be far removed in the ceilings or cornices, without risk of fire or of injury to the decoration. In short, it can be used in any position or for any purpose of illumination for which gas, oil, or candles are available, and for a great many for which they are not available. For outside illumination and large inclosures, the arc light gives a brilliancy and cheerfulness altogether unattainable by any reasonable expenditure of gas or oil. The convenience of the electric light has caused it to be highly appreciated, when it is found that by the mere pressing of a button a light is instantly obtained, which can be shaded over in any manner, without danger of setting fire to the fabric forming the shade. It also does away with the constant cleaning of globes or trimming of lamps. In respect of economy, the electric light does not as yet hold out the same decided advantages that it does in the other two respects just considered. In incandescent lighting, the cost of distribution is still heavy, though by increasing the electromotive force and the efficiency of lamps it is being much reduced. In arc lighting, the difficulty of subdividing and of reducing the amount of light given by one arc lamp renders it expensive for general outdoor street illumination, as compared with the present low prices of gas and oil. For the lighting of main streets and railway stations, or other places where a concentrated light is required, the arc light is, beyond question, far cheaper than gas, and its cost per candle power is but a very small fraction of that of gas. As the use of electric lighting extends, the cost of working becomes reduced; installations which four years ago cost 4d. per arc lamp per hour are now costing only 2d. The chief saving has been in the items of carbons and attendance, though the increased efficiency and durability of the apparatus have also greatly contributed to the reduction. Four years ago 11 millimeter or 0.43 inch hard carbons cost 4d. per foot. They can now be obtained for 1½d. per foot, or less than one-third. The following figures, supplied by the North British Railway, respecting the actual cost of working their electric lights at the Waverley station, Edinburgh, are interesting as showing how much cheaper it is becoming. The installation is worked by their own staff, and consists now of forty Brush arc lamps, supplied with a current of 10 amperes by a No. 8 Brush dynamo, which is driven by a semi-fixed engine.

July to December, 1884, Thirty-three Arc Lamps, 41,884 Lamp Hours.

	£	s.	d.
Wages.....	165	13	9
Repairs.....	47	2	6
Carbons.....	125	15	11
Coal.....	65	19	11
Oil, stores, etc.....	27	15	0
Interest and depreciation at 10 per cent.....	52	2	2

Equal to 2.77d. per lamp hour. £484 9 3

July to December, 1886, Thirty-nine Arc Lamps, 55,068 Lamp Hours.

	£	s.	d.
Wages.....	195	17	6
Repairs.....	78	9	6
Carbons.....	62	17	3
Coal.....	23	14	1
Oil, stores, etc.....	8	15	2
Interest and depreciation.....	41	10	6

Equal to 1.79d. per lamp hour. £411 4 0

In conjunction with these arc lamps, they are running 148 Brush Victoria incandescent lamps, distributed

* A paper recently read before the Institution of Mechanical Engineers, London.