the conditions of rotation? A little consideration will show us that if the mercury cups extend as before, and as in Fig. 9, to 180 deg. on each side, the arrangement will be in every way inferior to the one formerly considered; for the current is now shared between four conductors, in each of which there will be but one-quarter of the total current, and they cannot all be situated in the most advantageous position of the field where the attraction or repulsion of the magnet is the greatest. Moreover, some of them will positively be pulled forward while others are pulled backward. So though the current is just as strong as before, the altered distribution of the current is wholly disadvantageous, and the apparatus is both worse and heavier than before. Suppose, however, that the mercury cups are diminished till they subtend, as in Fig. 10, angles of but 90°, only two of the conductors can

dip simultaneously into the cup, and one will enter it just as another leaves it. Hence half the current will now traverse each; and if the sectorial mercury cups are judiciously placed so that their edge of first contact lies along CC', which we may call the "diameter of commutation," at right angles to the line joining the magnet poles, the two conductors in contact can never be far from the point where the attractive force of the magnetic field will have the largest effective leverage upon them. Better still will the machine be if the mercurial sectors are still further diminished, as in Fig. 11, down to 45°. Now only one conductor can dip in at once, but it will take the whole current, and as it passes out of contact the next will pass in. The increased weight of the fourfold conductor over the single bent wire of the first arrangement is more than compensated for by the advantage of always having in the most advantageous part of the field that conductor which is being acted upon. Instead of simply receiving an impulse once every half turn, the impulses come eight times during every revolution, and the rotation will therefore be much more uniform.

Once more let us remember what was pointed out at the close of the former article, namely, that every single wire we have considered may be replaced by a coil of many strands, and we shall realize the advance now made toward an efficient electro-motor.

Here, also, we may pause to note that if by the principle of reversibility we use mechanical power to rotate this system of conductors (or "armature" as we may call it), as it lies in the magnetic field, we shall obtain induced currents. And this new generator will possess corresponding advantages over the simpler arrangement that had only one bent wire, inasmuch as it will give both a stronger and a steadier supply of electricity; there being now eight successive currents generated during one revolution instead of two as before, and these currents will be more powerful, since the conductors in which they are generated are being moved through the most advantageous region of the field.

It is of course unnecessary to suppose the contacts to be made by cups of mercury, except that for light experimental bits of apparatus, the freedom from friction thus gained is of service. If the eight ends of these wires were brought down and soldered to a metallic collar on the axis, the collar being slit into eight separate parts, each of which successively came into contact with metallic brushes occupying the position relatively of the sectorial mercury cups, the same end would be attained, though with a little increased friction. With a larger number of conducting wires, the number of segments of the metallic collar or commutator would be increased, and their angular width proportionally diminished. This is in fact the kind of "commutator" which is used upon almost all the dynamo-electric generators in use.

We are now prepared to discuss the various systems of winding a Siemens armature. The actual system adopted by Von Alteneck and Siemens is a little complicated. In attempting to explain its nature, M. Breguet devised a similar system so closely resembling it that he at first thought it identical. He took a single stout wire and bent it up in the manner represented in Fig. 12, the two ends being sol-

dered to one another, and the separate bends so insulated as not to touch one another where they cross. Four little contact pieces were added at the corners, 1, 3, 5, and 7, to dip into mercury cups like those of the preceding apparatus, but with quadrantal sectors, as in Fig. 10. Now here the whole current obviously traverses each branch of the conductor, and the rotation will take place with more than redoubled energy; for the impulses will last during a whole quarter of

a revolution, and there will always be two wires attracted, and two repelled by each pole of the magnet. The same system is represented diagrammatically in Fig. 13, where,

however, a metallic collar slit into eight portions is supposed to replace the little contact pieces used for dipping into mercury cups. Of course more than eight vertical wires might be employed. Any regular polygon having an even number of sides would answer; but the octagon with star like points is very simple and effective, and answers all purposes. As before, each single wire of the simple experimental apparatus may be replaced by a coil of many turns; and the whole may be wound upon a longitudinal cylinder or core.

The actual method of winding up the bobbin of a Siemens generator—the method invented by Herr von Alteneck—is represented in a similar diagram in Fig. 14, from which it will be seen that the arrangement adopted has sixteen vertical conductors, and that it is an unsymmetrical one.

Curiously enough, a German engineer, Herr Frölich, who, like M. Breguet, intended to describe the Siemens (or Von Alteneck) armature, discovered another system of winding up the wires, which is shown in diagram in Fig. 15. Here

also there are sixteen vertical conductors arranged in pairs at the points of a regular octagon, and crossing the octagon by its diagonals at one end of the armature and by long chords crossing in the form of an eight-pointed star at the other.

There are, in fact, a large variety of ways of winding that coils upon a longitudinal armature, of which that adopted by Siemens is one, and not the best one. M. Breguet says he has found no fewer than eight. Of these there is one which appears to be better than all the others. It is represented in Fig. 16. Its superiority consists in requiring

the employment of a shorter length of wire to attain the same effects; which of course means not only a reduction of first cost, but a saving in the wasteful heating effects of internal resistance. In this system the portions of the coils which cross the ends of the armature to unite the sixteen vertical wires cross the octagon along short chords. As these end portions of the coils contribute little or nothing to the effective work of the motor or generator, it is a clear advantage that they should be as short as possible. M. Breguet has given the following as a table of the proportional lengths of wire necessary to make up end portions of equal sized armatures on the four systems:

System of Herr Frölich (Fig. 15)	30.8
" Von Alteneck and Siemens (Fig. 14)	30.5
" devised by M. Breguet (Fig. 13)	28.4
" " " (Fig. 16)	26.0

From which it appears that the last described arrangement is superior to all the others. Mr. Edison's latest generator is simply outwardly a Siemens armature placed between the two cheeks of a powerful upright electro magnet. It is not known yet what system of winding up of the wire he has adopted; though the armature possesses one peculiarity in having a number of strands of iron wire wound transversely between metal cheeks around the core, and the longitudinal coils of insulated conducting wire are wound on outside.

To this elegant investigation of M. Breguet there only remains one point to add, and it will form a fitting peg on which to hang our next and concluding article on the theory of the Gramme machine, namely, that the power of all these machines can be increased not only by increasing the number of turns of wire, and arranging them as advantageously as possible, but by increasing the intensity of the magnetic field in which they move by introducing iron cores into the very middle of the coils.

THE ELECTRIC LIGHT.

EXPERIMENTS are in progress at the North Shore Mills, Liverpool, under the direction of Mr. Ward, engineer of the British Electric Light Company, with the André incandescent lamp, which is said to possess several special advantages. The light is contained in a globe hermetically sealed, and, as the carbon rods are thus protected from contact with the air, they are not subject to combustion, or the combustion is so slow as to be almost imperceptible. The lamp is simple and effective. It is self-adjusting, devoid of mechanical appliances, and, as the carbon points are not consumed, it will remain illuminated for an indefinite length of time. The avoidance of any renewal of the carbon points is an obvious advantage, as is the fact that the new system admits of a complete subdivision of the current of electricity.

HYDROSTATIC BALANCE.

C. WACKERMANN, of Kalk (Prussia), has obtained a patent for the hydrostatic balance of which we give an illustration. It depends upon the well known law that a floating body weighs precisely as much as the volume of liquid displaced by it. Two open parallel cylindrical reservoirs, connected with each other at the bottom, *h*, are partly filled with a liquid, and two equally large and heavy hollow cylinders, *a*

and *b*, introduced into them. These latter cylinders are provided with top-plates, serving as scale-pans. When not loaded, the pans must be exactly opposite each other. Weighing, of course, is performed in the usual manner. The whole apparatus may be let into the counter or table, *h*, and, if the proper liquid is chosen, is not liable to get out of order.—*Dingler's Polyt. Journ.*

NEW LUMINOUS TUBES.

TRÈVE introduces a Fizeau condenser into a great Geissler tube. The two poles of a current from a Ruhmkorff coil terminate in this condenser, by means of the ordinary electrodes, which are soldered into the glass and are attached to the eleventh and twelfth sheets of tin foil. When the induced current passes into the condenser, if the tube still contains air at ordinary pressure, the usual rumbling is heard. If a vacuum is gradually made in the tube, the rumbling diminishes, and when the pressure falls to 0.003 or 0.004 m. (0.118 to 0.157 in.) no sound is heard; but a brilliant white light appears, shimmering like pearls from the leaves of the condenser, and entirely different from the phosphorescent, pale, and flickering light of the Geissler tube.—*Comptes Rendus.*

SIMPLE MERCURIAL AIR-PUMP.

By GEO. M. HOPKINS.

THE strong inclination on the part of experimenters, especially the younger ones, to repeat the brilliant experiments of Geissler, Sprengel, Crookes, and Edison, is apt to weaken when the expensive vacuum apparatus is considered. There are few glass blowers who can make a good Geissler or Sprengel pump, and it would be presumption for an amateur to venture on making this class of apparatus in the ordinary way.

Desiring something simple and inexpensive in the way of an air pump, I devised and constructed the pump shown in the engraving, which is simply a modified form of the Sprengel and Geissler pump as used by Mr. Edison. It was made entirely without the aid of a glass blower, and I may say without any glass blowing. Glass tubes, rubber tubes, corks, sealing wax, and mercury are materials that may be purchased almost anywhere; with these and two one-pint nasal douche bottles, a piece or two of board, a few screw eyes, and one or two other articles, the experimenter may begin the task of making the apparatus.

The board, *A*, 1 inch thick, 14 inches wide, and 54 inches long, has a narrow shelf, *a*, nailed to the upper end; and another similar shelf, *b*, secured to the front side 5 inches from the lower end of the board. A glass tube, *B*, 8 inches long, and 1 inch internal diameter, is fitted with two corks, *c*, *d*, whose length are about equal to their diameters. These corks are bored to fit the glass tubes which they are to receive, and are coated upon the ends, upon the sides, and in the holes intended for receiving the glass tubes with sealing wax.* A short glass tube, *F*, $\frac{1}{8}$ inch external diameter, is heated and coated with sealing wax; and while still hot, it is inserted in the hole in the cork, *d*, before the latter is placed in the tube, *B*. The cork, *d*, is now compressed and forced into the tube, *B*, leaving a space of $\frac{3}{8}$ inch between it and the end of the tube. The tube, *B*, is then warmed by turning it carefully in a flaring gas or alcohol flame until the wax on the cork melts, when the space between the outer end of the cork and the end of the tube is filled with sealing wax, as shown in Figure 2, and allowed to cool. A glass tube, *C*, $\frac{1}{4}$ inch internal diameter, and 32 inches long, is bent at one end at a right angle, to receive the rubber mercury supply tube, *D*, $4\frac{1}{2}$ feet long. The bending is very easily accomplished by holding and turning the tube in an ordinary gas or alcohol flame until it is soft, when it may be readily bent into the required form. The straight end of the tube, *C*, is heated, coated with sealing wax, and inserted in the hole in the cork, *c*, so that it comes just even with the upper side of the cork.

After it has cooled, the cork is inserted and secured in the same manner as the cork, *d*. The object in heating the tube, *B*, after the corks are inserted is to melt the wax on the sides of the cork, so as to cement the cork firmly to the glass and prevent it from being forced inward by atmospheric pressure. A hollow is cut out of the board, *A*, to receive the tube, *B*, and the tube, *C*, is fastened by a copper strap, *f*, screwed to the board and pressing the short section, *e*, of rubber tubing which surrounds the tube, *C*. A flexible rubber tube, *D*, is slipped over the lower end of the tube, *C*, and is connected with the douche bottle, *E*, containing mercury.

The tube, *F*, is secured to the board, *A*, in the same way as the tube, *C*; and as this method of fastening the tubes is used throughout the apparatus, it will be unnecessary to al-

* A round rod of iron heated and used something after the fashion of a soldering iron will be found convenient for melting and applying the wax.

FIG. 1.—SPRENGEL PUMP; GEISSLER PUMP.

FIG. 2.—SECTION OF GEISSLER PUMP. FIGS. 3 AND 4.—JOINTS.
FIG. 5.—SECTION OF MERCURY RECEIVER.

lude to it again. A very thick rubber tube, G, is slipped over the tube, F, at one end, while the opposite end is slipped over the end of the glass tube, H, which is about $\frac{1}{8}$ inch internal diameter, and 38 inches long. The ends of the tubes, F, H, which are inserted in the rubber tube, G, are varnished with shellac, and the tubes are inserted while the varnish is still green.

In the upper portion of the bent rubber tube, G, a notch

FIG. 6.—LONGITUDINAL SECTION OF SPRENGEL PUMP.

is cut with a sharp knife (moistened with water to facilitate cutting) and the end of a rubber tube, I (6 inches long), is fitted to the notch and cemented in as shown in Figure 4, with a cement composed of equal parts of pitch and gutta-percha melted together and used hot. *p* represents the cement surrounding the joint. The tube, I, extends upward through two copper straps, *ff*, and is provided with a pinch-cock, J, consisting of a bar of hard wood beveled on its inner surface, and operated by an ordinary screw-eye, *g*, which passes through it into the board, A.

The upper end of the tube, I, is intended for receiving a glass or metal tube connected with the vessel, K, to be exhausted. This vessel in the present case is a Geissler tube.

Between the straps, *ff*, a rubber tube, M, is connected with the rubber tube, I, in the same way as the latter is connected with the tube, G; but, for the present, all mention of the tube, M, will be omitted. As the Geissler pump, consisting of the tube, B, and its connections, will be found a very useful instrument when taken alone for many purposes, its construction and operation will be described independently of the Sprengel pump connected with it by the tube, M.

The lower end of the tube, H, dips in a vessel, L, partly filled with mercury. This vessel, in the present instance, is simply a gallipot with a small hole drilled through its side, and fitted with a mercury discharge tube, *h*, furnished with a flexible pipe, *i*, leading to a mercury receiver. Fig. 5 shows the gallipot, L, with its discharge tube, *h*, and the tuft, *j*, of cotton or wool for preventing the mercury from splashing.

The operation of producing a vacuum by means of the Geissler pump just described is to first screw down the pinch-cock, J, by means of the screw-eye, *g*, then raise the mercury bottle, E, until the mercury rises in the tube, C, fills the larger tube, B, flows over the bend in the pipe, G, and discharges through the tube, H, into the gallipot, L. At this moment the mercury bottle, E, is lowered, allowing the mer-

cury column to break in the tube, G, a small portion falling in the tube, H, while the larger portion descends in the large tube, B. As soon as possible after the mercury begins to fall, the pinchcock, J, is opened, and the descending mercury draws the air from the Geissler tube, K. As soon as the mercury has dropped as far as it will, the pinchcock, J, is closed, and the operation is repeated over and over again until the mercury in the tube will stand about 28 or 29 inches in height, measuring from the upper surface of the mercury in the bottle, E, when the latter sets upon the floor.

The smallest amount of mercury that can be used with this pump is 5 lb. It will be obvious that, by enlarging the tube, B, the capacity of the pump may be increased, but if it is made on the plan represented in the drawing, some difficulty

may be experienced in making good tight joints at the ends. It would be better to have a vessel made like a bottle, with no bottom, but having a neck on each end into which the tubes, C F, might be inserted. The rubber tubes, G I M, should be thick enough to resist atmospheric pressure when a good vacuum has been formed.

When the Geissler pump alone is used, the rubber tube, M, will not be attached. The joint between the rubber tube, I, and the tube inserted in it at the top is rendered perfect by the application of a little vaseline, and this substance may be used to stop slight leaks, should any occur; and should the rubber tubes be suspected of porosity, they may be entirely covered with vaseline.

In working the Geissler pump, the mercury that overflows from the gallipot, L, may be poured from time to time into the bottle, E.

This pump may be used for all purposes in place of the ordinary piston pump, but when a more perfect vacuum is required, the Sprengel pump connected with it by the tube, M, must be used.

The Sprengel pump has a tube or barrel, N, 4 inches long and $\frac{5}{8}$ inch internal diameter, in the upper end of which is secured a cork, k, through which pass two small glass tubes, O P, about $\frac{1}{2}$ inch internal diameter. The tube, O, is connected by a rubber tube, R, with the douche bottle, S, standing on the shelf, a. The tube, R, is furnished with a pinch cock, T, operated by the screw eye, g. The tube, O, projects about

$\frac{3}{4}$ inch below the cork, k, while the tube, P, passes just through, and is bent at a right angle to receive the tube, M. The cork, k, is placed $\frac{5}{8}$ inch below the upper end of the tube, N, to form a cavity, l, for receiving a small quantity of mercury, which seals the joint and supplements the sealing wax used in fastening the cork, k, and prevents the entrance of air.

The lower end of the tube, O, is bent as shown in Figure 6, to bring it directly in the axis of the tube, N.

A cork, m, fitted to the lower end of the tube, N, is bored to receive the glass tube, Q, which is $\frac{1}{8}$ inch internal diameter and 28 inches long. The cork, m, is carefully coated with sealing wax, and the tube, Q, is cemented into it; and

upon the upper end of the tube and cork a quantity of sealing wax is built up, forming a conical mouth, o, for the tube, Q. The sealing wax, when cool, is cut with a penknife into the required form. It may then be warmed quickly over a small pointed flame to give it a smooth glossy surface. The tube, Q, with the cork, m, and flaring mouth, o, attached, is now inserted in the lower end of the tube, N, and fastened by heating the tube as in the case of the Geissler pump; the lower end of the tube, N, is then carefully sealed around the tube, Q. A common wooden pill box, n, bored to receive the tube, Q, and supported by a cork which is bored and cemented to it, is partly filled with mercury to seal the lower end of the tube, N.

The glass tube, Q, is supported in the same way as the tube, C, and the arrangement of the gallipot, L, tubes, h' i', and mercury-receiving vessel, is the same as in the case of the Geissler pump.

The operation of the Sprengel pump is quite different from the Geissler. It depends upon the continuous dropping of mercury from the lower end of the tube, O, into the mouth, o, of the tube, Q. Each drop acts as a liquid piston, carrying downward before it a quantity of air. The flow of mercury is controlled by the pinch-cock, T. When the falling mercury incloses no more air, and the drops strike the top of the mercury column contained in the tube, Q, with a sharp clink, the vacuum is nearly complete.

Five pounds of mercury can be made to work this pump quite well by having two mercury receivers at the bottom, and pouring the mercury back into the bottle, S, as often as it becomes nearly exhausted, but it is better to use 10 or 15 pounds. The Sprengel and Geissler pumps may with advantage be used together, the latter being used for removing the bulk of air, the former being employed in completing the vacuum.

The manner of using the two together is as follows: The Sprengel pump is first started by opening the pinch-cock, T. The pinch-cock, J, being closed, the Geissler pump is worked as before described, but instead of simply exhausting air from the Geissler tube, K, it exhausts it from the Sprengel pump. When the vacuum is sufficient to sustain a column of mercury 28 or 29 inches high in the tube, Q, the Geissler pump is shut off by closing the pinch-cock, J, when the operation is completed by the Sprengel pump.

Supposing the vessel being exhausted to be a Geissler tube.

to air pressure as the counter pressure is removed from beneath it by the pump.

Fig. 9 shows the effect of air pressure when the jar is closed with a piece of bladder which is non-elastic. The air pressure in this instance bursts the bladder with a loud report.

Figure 10 shows the arrangement of a flask partly filled with water which is quite warm, but not boiling hot. On connecting this with the pump and removing the air pressure from the surface of the water, it begins at once to boil. Ether will boil at a comparatively low temperature in a vacuum. It is not advisable, however, to perform this class of experiments with the pumps above described, as moisture interferes with their operation; and should any accumulate on the inner surface of the tubes, they should be dried at once by means of cotton wound upon the end of a wire. Although these pumps are easily made and inexpensive, they serve a really good purpose and will doubtless prove serviceable to many readers of this journal.

THE THEATER PRAXINOSCOPE.

M. REYNAUD, the inventor of the "praxinoscope," has recently modified this popular toy so that the moving figures seem to be in relief, and, by the addition of proper scenery, the same effect is produced on the observer as if he were looking in upon a liliputian theater in which living actors were performing. In this new apparatus, which the inventor called the "theater praxinoscope," the figures in their different poses are first sketched on a black ground; then, to obtain the scenic effects, an image of an appropriate design is projected on the black ground by means of a sheet of plain glass. The property possessed by a transparent sheet of plate glass of giving, by reflection, an image of objects situated in front of it, and at the same time of allowing objects to be seen which are placed behind it, is well known; and this same effect of optics has already been made use of in theaters in ghost scenes. In the toy under consideration the scenery is placed in the cover of the box, and this is kept in a vertical position by means of a hook, as shown in the annexed figure. In this cover there is a rectangular opening, through which the spectator (looking with both eyes) perceives at the same time both the moving image of the praxinoscope and the fixed image of the scenery reflected

THE THEATER PRAXINOSCOPE.

the vacuum is tested from time to time by passing sparks through it from an induction coil. When the proper degree of vacuum is attained, the Geissler tube is sealed off by applying to the glass tube that connects it with the rubber tube a gas or alcohol flame, and pulling and twisting the tube when soft so as to temporarily seal the tube. The tube has a second sealing at the hands of the glass blower.

When the vacuum is such as to prevent the passage of sparks between points $\frac{1}{4}$ inch apart in a vacuum tube it may be considered very perfect. A small Geissler tube is sometimes connected with the vacuum apparatus as a gauge to indicate the perfection of the vacuum.

If desired, all the joints in the apparatus may be sealed with mercury as in the case of the tube, N. Instead of the gallipots wooden pill boxes may be used. They should be well coated with shellac outside and inside.

The success of either of the pumps above described depends in a great measure on having the tubes perfectly clean and upon using clean mercury.

Figures 7, 8, 9, and 10 show some of the common air pump experiments that may be readily performed by using the Geissler pump alone.

Fig. 7 shows a plate having a tube extending from its center to the side of its base to receive a flexible tube connecting it with the tube, I. To the plate, which may be of brass ground to a perfectly level surface, a bell glass is fitted by grinding it with emery and water upon another level surface such as a piece of plate glass. To the center of the top of the bell glass is cemented a silk cord carrying at its lower end a bell. Near this cord is cemented another similar one supporting at its lower end an iron ball which hangs near the bell but does not touch it.

By exhausting the air from the bell glass and then swinging the bell hammer by means of a magnet until it strikes the bell, the fact that rarefied air is incompetent to conduct sounds is at once manifest. The same bell glass may be used for other experiments. To improve the joint between the bell glass and the plate, the latter may be smeared with vaseline.

It is not absolutely essential that the plates or bell glass be ground perfectly true, if a ring of very elastic rubber be used under the edge of the glass.

Fig. 8 shows a jar covered with elastic rubber which yields

on the plate glass. The inclination of the latter and its distance from the scenery are such that this image seems to be behind the moving object, and, consequently, the latter appears to be actually in relief on the stage. The box cover is provided with a slit, through which the scenery is inserted, and a small shelf for it to rest upon. By having on hand, then, a supply of chromos, representing landscapes, buildings, the interior of a circus, etc., it is easy to select a proper scene to accompany each of the different moving objects placed in the praxinoscope. The toy works equally as well in the evening as in the daytime. To use it by daylight it is only necessary to place the apparatus before a well-lighted window; at night the same effects will be obtained by simply placing in the candlestick at the center of the praxinoscope a wax candle provided with a small silvered reflector and a shade. The illusion produced by this scientific plaything is said to be very complete and very curious.

EDMUND HALLEY: HIS LIFE AND WORK.

ON June 12, 1874, Prof. Adams, President of the Royal Astronomical Society, called the attention of the members at the meeting to the original labors of Jeremiah Horrocks in connection with the then forthcoming transit of Venus; the result being the erection of a memorial to Horrocks in Westminster Abbey. Several of those who took then such a keen interest in the noblest of astronomical problems (one of whose keys was about to be unlocked by the keen observers of various nationalities) have passed away; but the veterans who survive, together with an ever-increasing crowd of junior recruits, are now looking forward to the next recurrence of the infrequent transit, and on this occasion we may well devote a page to an outline of the life of the famous Dr. Halley, whose name is so well known, but whose history has yet to be written. For beyond more or less unsatisfactory and inauthentic sketches of his career, no actual scientific biography of our grand countryman exists. The want of such a work will, we believe, be ere long supplied by the Savilian Professor of Astronomy at Oxford, in whose hands the mass of material collected by the late Prof. Rigaud rests; so that the result of the editorial labors of the Reverend Professor Pritchard may be looked for at an early date. Meantime we may briefly recapitulate what is