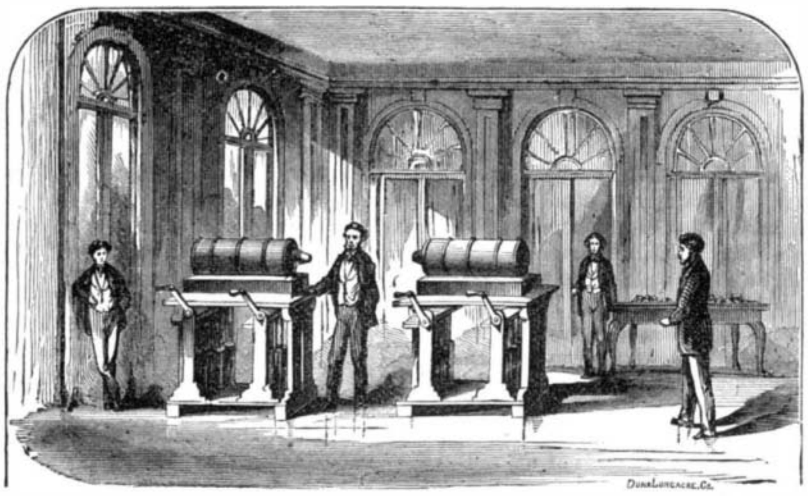
MAGNETO-ELECTRIC MACHINES.

LECTURE DELIVERED AT THE STEVENS INSTITUTE OF TECHNOLOGY, BY PROFESSOR GEORGE F. BARKER, OF THE UNIVERSITY OF PENNSYLVANIA.

It will be remembered, from the previous lecture (see page 181, current volume), that every magnet is surrounded by a field of force, consisting of lines of force proceeding from it in every direction; and that whenever these lines are traversed or cut by a conductor, a current of electricity will be developed in the latter, which is the more powerful the more nearly the lines of force are cut at right angles. This is the principle of the magneto-electric machines to be described. It may not be superfluous to define a magneto-electric machine as one in which magnetism is used to produce electricity, while an electro magnetic machine is one in which electricity is used to produce magnetism.

In 1831, Faraday proved the conversion of magnetism into electricity, by using a flat iron ring having on both sides a carefully insulated coil of wire. On passing a current through one coil, a galvanometer needle connected with the other coil was deflected. Now, this could only be effected by an induced current, and this current could only be due to the magnetism produced in the iron ring by the first coil—a result which Faraday undoubtedly foresaw when he constructed his apparatus.



THE GREAT ELECTRO-MAGNETS AT THE STEVENS INSTITUTE.

The principle of this discovery was then shown by the lecturer by introducing a very small magnet into a small coil of wire connected with a galvanometer needle, which was projected on the screen by means of the lantern. It was observed that the needle was deflected in different directions, according as one or the other pole of the magnet was introduced into the coil, or as one or the other end of the coil was selected for the introduction of the magnet. It was further observed that the effect was produced only at the instant of introducing and at the instant of removing the magnet from the coil. Here, then, we have the condi tions requisite for the construction of a magneto-electric engine. We know that the lines of force must be frequently cut at right angles, and the whole problem becomes a mechanical one: How can it be done to the best advantage?

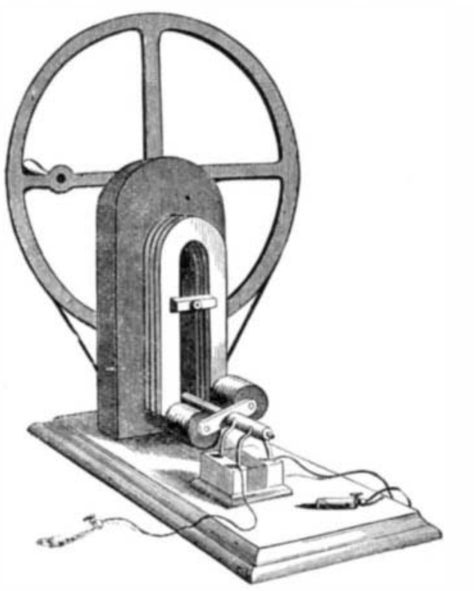


Fig. 1.—CLARK'S MAGNETO-ELECTRIC MACHINE.

So soon as the year following Faraday's discovery, Pixii, an instrument maker of Paris, made a magneto-electric engine for the celebrated Ampère. In this machine, the steel magnet revolves on a vertical axis below two coils of wire containing soft iron cores. The electrical current induced in the wire was strong enough to decompose water, melt thin platinum wire, and replace the battery in all respects.

The same year (1832), our distinguished countryman, Joseph Saxton, long employed in the Philadelphia Mint and the United States Coast Survey, used a stationary horizontal magnet, and revolved a series of four coils before its poles As Professor Joseph Henry had observed marked differences of effect with different thicknesses of wire, Saxton made two of his coils of fine and two of coarser wire. Now when the coils revolve before the poles of the magnet, currents in opposite direction are induced in them in the two halves of their revolution ;and in order to throw these opposite currents in one direction, he invented a commutator, consisting essentially of double points of metal, connected with the axis of rotation, and making connection by dipping into a cup of mercury, so as to carry off each current before the next is produced. In other machines, the same is effected by insulating, on the axis of rotation, all but two strips, connected with the coils, and carrying off the current by means of metallic springs pressing against it.

As Saxton did not publish a description of his machine, although he had it exhibited in London for a long time, Clark, a London instrument maker, brought out, in 1836, the machine represented in Fig. 1, which is in its principles a copy of Saxton's, with the exception of the commutator.

In the next place, Page took two magnets and revolved his coils between them. This was the first machine made in America; and from this time on, greater power was sought by the multiplication of parts. Stöhrer, of Dresden, used three magnets and numerous coils, and, finally, Professor Nollet constructed an immense machine containing no less than 56 magnets, between the poles of which numerous bobbins or coils were revolved by steam power. With 300 revolutions a minute, an electric light was obtained from it, equal to 75 carcel burners or 500 candles, at a cost of 30 cents an hour. It had taken, before, 226 Bunsen cells to produce the same light, at a cost of $2.30 an hour. The lighthouse of Cape La Haye, near Havre, is furnished by this machine, and the lights on the British Coast

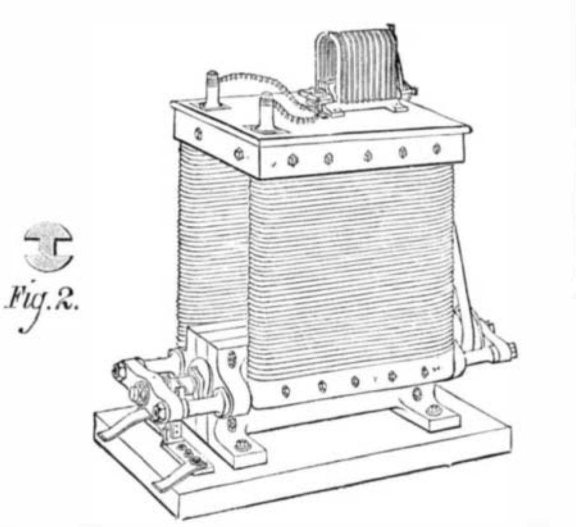


Fig. 3.—WILDE'S MACHINE, WITH SIEMENS' ARMATURE.

are made with the Holmes improvement of the same machine.

It was plain that no further improvement was possible in

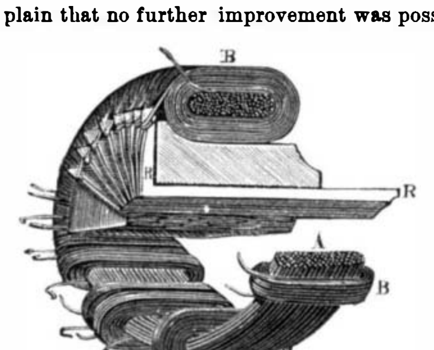


Fig. 4.—COIL OF GRAMME'S MACHINE.

the direction hitherto adopted, as there was a practical limit to the amplification of parts. It was then remembered that the magnetic field of an electro-magnet was much more powerful than that of a permanent one, and that electro-magnets could with advantage be substituted for ordinary magnets, as they occupied much less space, and made a more compact machine. This result was favored still more by the invention of the Siemens armature in 1857. This was a new device for cutting the lines of force, in the place of the revolving coils or bobbins. It consists of a long soft iron bar, a cross section of which is shown in Fig. 2. The grooves represented there serve for the reception of the insulated wire, which is wound lengthwise over the bar. In order to use this new form of armature, the electro-magnet, between the poles of which it revolves, is made long and flat, as in Fig. 3, which represents the Wilde machine with the Siemens armature. A small magnet on top induces a current of electricity in the wire of a small armature, which in turn charges the large electro-magnet below, and produces a powerful current in the wire of the large armature. There are two of these machines in this country, one in Boston and one at the printing establishment of Frank Leslie, in New York. The latter is driven with a velocity of 1,800 revolutions per minute, and the current derived from it will electrotype several plates of his paper in twenty minutes. It is also used as a source of of electric light for photographing on cloudy days.

But a yet further improvement was made in this machine. Siemens and Wheatstone proposed to do away with the small magnet entirely. That looked very much like perpetual motion. What is there to start the machine? There is always enough residual magnetism left in the armature, when the machine has once been started, to produce a feeble current of electricity; and if this is made to flow into the wire surrounding the large electro-magnet, it will charge it sufficiently to increase the current by which it is supplied. In this way, the large electro-magnet soon gains its full strength. The principle of such machines is, therefore, to divert a portion of the induced current back into the electro-magnet, and use the remainder for outside work.

Ladd, a London instrument maker, constructed a machine on this principle, which received the first prize at the Paris exhibition of 1867.

The next improvement was made by Professor Pacinotti, of Pisa, who made his armature in the form of a ring, so

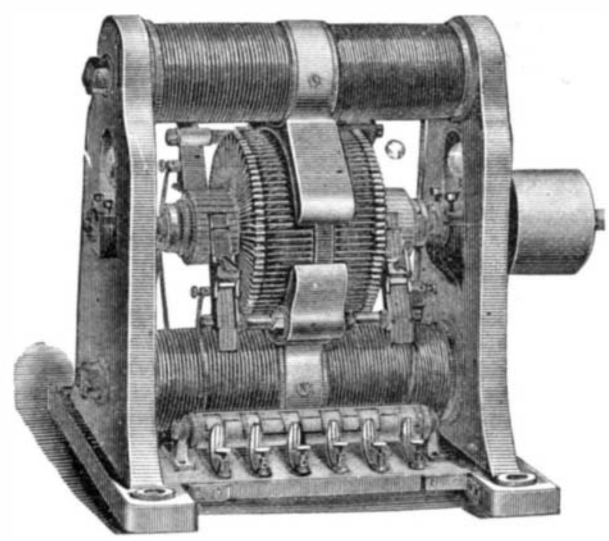


Fig. 6.—IMPROVED FORM OF GRAMME'S MACHINE.

that the current should always flow in one direction. It consisted of a ring of soft iron, surrounded by insulated wire, and revolved between the poles of the existing magnet. The current was tapped and carried off half way between the poles.

This form was almost forgotten, when, in 1871, M. Gramme, a furniture dealer and general tinker of Paris, was led to construct a machine by studying one that had been brought to him to mend. The principles involved are of importance, as they led to the most perfect instrument of the kind yet invented. Conceive, as was shown by the lecturer, that a bar of soft iron, surrounded by insulated wire, is subjected to the influence of one of the poles of a permanent magnet, say the north pole. Let this magnet be passed gradually over the length of it. Then there will be produced a south pole in the bar wherever the magnet happens to be, beginning at one end and stopping at the other. At the same time a continuous current will flow in the coil as long as the motion lasts. Now, suppose this bar with its coil to be made in a ring and revolved before one pole of a magnet, and we have the same conditions in the best available form. If such a ring be revolved between the two poles of a magnet, however, they will act on it in opposite directions, and the currents so formed will constantly tend to neutralize each other at two points half way between the poles. In order to utilize both currents, it is only necessary to tap the neutral points by means of conducting wires. Fig. 4 shows the method of winding the coils adopted in practice. The wire, B, is divided into sections, say of 300 turns each, but there is no break in passing from one section to the other. A loop of the wire only is left exposed; and this is connected with a copper conductor, R, bent at right angles so as to pass through the ring. When the ring is revolved, several of these conductors touch

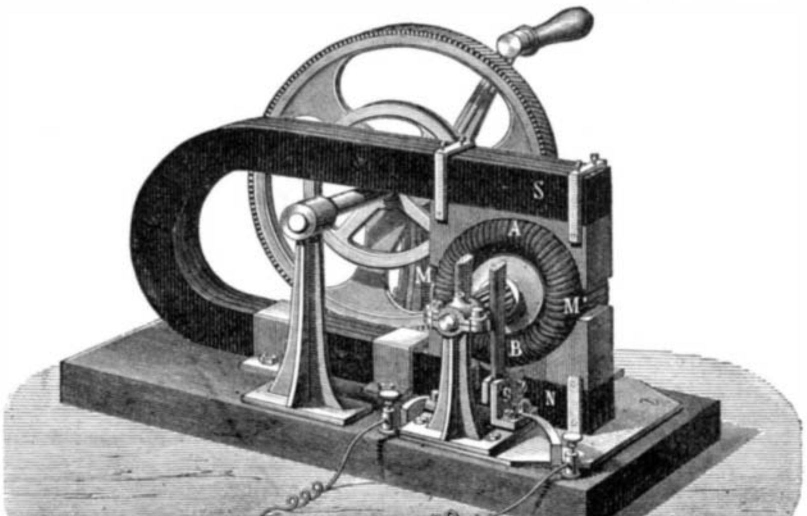


Fig. 5.—GRAMME'S MAGNETO-ELECTRIC MACHINE.

two metallic rubbers or brushes, by which the current is carried off. The rubbers or brushes are so arranged as to be always in contact with more than one of the conductors.

The original Gramme machine, which was exhibited before the French Academy of Sciences by M. Jamin, is represented in Fig. 5, in which the circular armature already described was revolved by hand between the poles of a permanent magnet. Since that time M. Gramme has made a great many important changes and modifications in his machine, the most notable of which are the substitution of electromagnets for permanent ones; the adoption of the dynamic principle, as it is called, of starting the machine by its own residual magnetism; and the adaptation of a single armature to the purposes both of electroplating and the electric light. Fig. 6 represents the latest form of this machine. It is the one which was used by the lecturer. Its dimensions are 22 inches in every direction and its weight is 500 lbs.

This machine was driven by means of the engine in the workshop of the Institute in the basement below, the belting passing through the floor of the stage. The electric light so produced was of intense brilliancy. A dynamometer was attached to the instrument in order to measure the power used, and a class of Institute students was in attendance to take notes. They also studied the photometrical measurements made, to determine the intensity of the light. Their notes will be worked out with the greatest accuracy.

For the photometrical measurements, the lecturer placed the electric lamp in the rear of the hall, some 60 feet away, and caused it to cast a shadow of the pointer he used to show the parts of apparatus exhibited, on the screen. Then, on taking a standard candle and causing it to cast another shadow of the same object, he carefully approached the candle to the pointer until the intensity of the shadows was the same. Supposing this distance to be 2 feet, then will the light of the electrical lamp be to that of the candle as 2^2 is to 60^2, which is as 1 to 900; or in other words, the electric light yielded is equal to 900 candles. The actual light obtained, however, was still more powerful.

Professor Julius Thomsen, of Copenhagen, by an ingenious method of converting the light rays into heat, has calculated the mechanical equivalent of light (that is, of a standard candle) to be equal to 13·1 foot pounds per minute. Now, as one horse power is 33,000 foot pounds, the theoretical maximum amount of light obtainable from one horse power is $\frac{33000}{13.1}$ or 2,518 candles. In practice, the lecturer obtained in round numbers about 1,000 candles per horse power. The best effect was obtained when the carbon points were $\frac{3}{16}$ of an inch apart.

The lecturer in the next place threw on the screen a magnificent image of the carbon points, and showed the spectra of the solid and of the vaporized carbon. He concluded his lecture by removing the belt, which connected the machine with the engine, and connecting the powerful battery in the basement of the Institute with the brushes of the machine. The latter immediately began to rotate with great rapidity, and it was stated that 70 per cent of the power could thus be utilized.

The same machine has also been used by President Morton to exhibit all the experiments connected with a lecture on spectrum analysis to his class at the Institute, and so convenient did it prove that scarcely an hour was required to prepare all the requisite apparatus. C. F. K.

The Iron Works of the United States.

We are indebted to the American Iron and Steel Association, Philadelphia, Pa., for a copy of their "Annual Directory" of the iron and steel manufacturing establishments of this country. It is an important and valuable document, giving particulars in detail of all establishments connected with the above industries. The following is a general summary:

Whole number of completed blast furnaces, Jan. 1, 1876..	713
Annual capacity of all the furnaces, in net tuns..........	5,439,230
Whole number of rolling mills, Jan. 1, 1876	332
Whole number of single puddling furnaces (each double furnace counting as two single ones)................ ..	4,475
Total annual capacity of all rolling mills in finished iron, net tuns..................	4,189,760
Annual capacity of all the rail mills, in heavy rails, net tuns................	1,940,300
Number of Bessemer steel works, Jan. 1, 1876............	11
Annual capacity in ingots, net tuns....................	500,000
Number of Bessemer converters....	24
Number of open hearth steel works, Jan. 1, 1876..........	16
Number of open hearth furnaces.........................	22
Annual capacity in ingots, net tuns	45,000
Number of crucible and other steel works, Jan. 1, 1876....	39
Annual capacity of merchantable steel, net tuns........	180,250
Of which there are of crucible steel, in net tuns..........	45,000
Number of Catalan forges, making blooms direct from the ore, Jan. 1, 1876..........	39
Annual capacity in blooms and billets, net tuns...........	59,450
Number of bloomaries, Jan. 1, 1876, making blooms from pig iron......	59
Annual capacity in blooms, net tuns......................	60,200

A New Mucilage.

The *Journal de Pharmacie* states that if, to a strong solution of gum arabic, measuring 8½ fluid ozs., a solution of 30 grains sulphate of aluminum dissolved ⅔ oz. water be added, a very strong mucilage is formed, capable of fastening wood together, or of mending porcelain or glass.

A NEW nickel-plating solution, said to yield beautiful results, is prepared by mixing the liquid obtained by evaporating a solution of ½ oz. nickel in aqua regia to a pasty mass and dissolving it in 1 lb. aqua ammonia, with that obtained by treating the same quantity of nickel with a solution of 2 ozs. cyanide of potassium in 1 lb. of water. More cyanide renders the deposit whiter, and more ammonia renders it grayer.

Correspondence.

Small Engines for Agricultural Purposes.

To the Editor of the Scientific American:

As many of your readers are interested in the performance of small engines, I will tell you what we have accomplished with one, diameter of cylinder of which is 3 inches, and length of stroke 5¼ inches. I can only give you the amount of work done, as we have neither steam gage nor water glass. On February 2, we threshed 239 bushels of oats inside of 5¼ hours. The thresher was 120 feet from the engine, and was driven by ½ inch seagrass rope from engine to idler, thence by 3 inch belt to thresher. The snow drifted on to the engine so that it was nearly covered: the parts that were hot, however, kept the snow thawed. The boiler is of our own design, built entirely of 1 inch gas pipe, and has about 50 feet of heating surface. I have taken your paper for years, but I have never seen any design at all like this one. It works to a charm, does not leak a drop, and will stand immense pressure. It holds but 3 pails of water, and is as easily managed as any 36 or 40 horse shell boiler; and I have had some experience with such sizes. We have designed a pump expressly for this boiler, and I will venture to say it cannot be beaten for one holding so small a quantity of water. The amount of fuel used in threshing the grain abovementioned was 4½ cords of old rails, cut to two feet lengths. The engine made about 300 revolutions per minute, working steam at full stroke. I can give you no better data, but I think the results are hard to beat. We are farmers and not machinists, but we have constructed the entire engine and boiler. L. COOPER.

Cortlandville, N. Y.

Photo Suggestions.

We have long been familiar with the fact that telescopic images may very easily be produced in the camera by the simple expedient of mounting a small camera upon the eyepiece end of the telescope, the degree of amplification depending upon the distance between the eyepiece and the sensitive plate. As might be anticipated, the amount of angle included is exceedingly small, the object glass of a telescope being corrected only for axial rays; and indeed, owing to the tube, the transmission of an oblique ray would be quite impossible.

It may not be generally known that, by means of an opera glass used as a camera objective, a greatly enlarged image of any view to which it is presented may be obtained. Owing to the shortness of the tube, and to the optical principles involved in the formation of a large image by means of an objective when used in conjunction with a concave eyepiece, this form offers advantages, in the production of a directly magnified image, not possessed by the ordinary telescope. We recently made several experiments with an instrument which, owing to its expense and the niceties involved in its construction, is very seldom manufactured. It has a short body, about four inches in length, but possesses very great magnifying powers, attributable to its construction. It is comprised of three triplet lenses in each tube: an object glass of large diameter and short focus—not plano-convex, but rather as the form known as crossed; a center bi-concave triplet of large diameter and great curvature; and a plano concave triplet eyepiece, the flat piece being next the eye. This form of tube, when used as an objective for the camera, produced images of great sharpness in the axis, the sharpness being more extended than we have seen it with any other form. By means of this instrument we obtained an excellent and sharp photograph of the sun three inches in diameter.—*The British Journal of Photography.*

Preparing Relief Blocks from Photographs.

A German process for getting surface blocks from photos, to be printed by letterpress process, is: Take a piece of looking glass about 2½ inches larger all round than the original, and pour on it, in the dark room, the result of 1 oz. bichromate of potash in 15 ozs. water, put over a slow fire, and add gradually 2 ozs. of fine gelatin. When dissolved and at boiling point, strain through a fine linen rag.

The plate must be placed in a horizontal position. Spread all over with a fine broad brush. Give fresh layers till the film reaches about a line and a half thick. Let dry for two or three days, and keep from the light. Take a glass positive from the negative of the original; place the prepared plate in contact with it in the printing frame. Remove to the dark room; pour over tepid water till fully developed. Dry with filtering paper, paint over with glycerin, and wipe off also with filtering paper. Develop the relief upon the plate; its subsequent treatment need not be effected in the dark. To make the plaster mold, mix fine plaster of Paris with spring water in two vessels, to the consistence of oil in one, of thick cream in the other. Hold the plate in the hand, pour over it the thinner solution, tap the bottom of the plate gently with the hand to prevent air bubbles. Place the plate horizontally upon the table, and pour the thicker solution over to a moderate hight. Leave it to settle and dry for some 16½ hours. Cut away the thin edges of the gypsum with a knife. Separate the plaster mold gently from the relief plate. Pour stereo metal into the mold, and a printing plate will be the result. Rectify defects with fine-pointed tools in the plaster mold previously to casting.

ACCORDING to M. Tisserand, the French Inspector General of Agriculture, milk will yield more butter and cheese when the pans are set in an apartment where the temperature is not higher than 32° Fah.

Weighing Light.

The London *Times* gives the following description of Mr. William Crookes' new apparatus for weighing a ray of light: In a tube in which a vacuum has been produced, a very fine thread of glass is suspended by both ends, and at one part of it is a small cross thread, to which is attached a disk of pith with one side blackened. At the junction of this cross piece is a small circular mirror, so arranged that a ray thrown on it from a lime light shall be reflected on to a graduated scale, and any twisting of the glass thread shall be thus recorded. At one end of the glass thread is a turning disk and a Harding's counter, outside the tube. The light to be weighed is allowed to fall on the pith. This, as in the simple radiometers, is repelled, and its motion causes a torsion of the glass thread and a motion of the mirror spot along the scale. The turning disk is employed to unwind the thread against this action, the mirror spot going back to zero on the scale. The counter tells the degree of torsion the glass thread has undergone by counting the amount of unwinding required. Then a little iron weight, the one hundredth of a grain, which is within the tube, is lifted by a magnet on to the cross bar; its weight causes a torsion, the mirror spot travels along the scale, and the unwinding is performed as before. A candle placed six inches away from the pith was found to give 1,628 degrees of revolution, and the little iron weight 10,021 degrees. The candle light is therefore calculated to weigh 0 00172 grains. Mr. Crookes has made experiments on the sun's light, and has worked out some calculations on it It is equal to 32 grains on the square foot, 57 tuns on the square mile, or 3,000,000,000 tuns on the whole earth.

There are two practical applications of this discovery which bid fair to be of considerable scientific value. The first is its employment as a photometer. If, for instance, the candle light above noted weighs 0·00172 grains, that weight could be made to cause a certain deflection of a dial finger. With this might be compared the deflection caused by any other light, and thus the intensity of one illuminator conveniently measured by the other, used as a standard. Mr. Crookes tried this, and found that a correspondence between the light of a candle flame and that of a gas burner took place when the candle was 48 inches and the burner 113 inches distant. Consequently the light of the burner equaled in intensity that of 5½ candles. This gives a way of testing any burner, the deflection due to the light of which, when good gas is employed, is previously known. If the deflection should fall short, then gas of poor quality would be presumed. So also the varying intensities of sunlight might be measured, and this would prove a valuable addition to meteorological records.

New Lion Palace, Zoological Gardens, London.

The lion palace is two hundred and fifty feet long outside and two hundred and twenty-seven inside; the width of the asphalt pavement in front of the dens is thirty-six feet, the height is thirty-four feet. There are altogether fourteen dens, four large ones, one at either end, and two in the center; they are twenty feet long by ten feet wide, the smaller are about twelve feet square. The supports to the roof are varnished wood, such as is seen in new churches, and the blue tint given to the ceiling gives a general lightness to the whole edifice. The floors of the dens are sloped towards the front, and just outside, in front of the whole series of dens, there is a trough which has a constant flow of water running through it, so that the cleanliness and the comfort of the animals have been provided for in every possible way. The ventilation and warming apparatus is most perfect.

The following is a list of the animals: No. 1, "The Shah," a Persian lion; No. 2, lioness, East Indies; No. 3, Indian leopard and a Nubian lioness; No. 4, Indian leopard; No. 5, clouded tiger; No. 6, three Mexican pumas; No. 7, two lionesses and one lion, born in menagerie, July 8, 1872; No. 8, Indian tiger; No. 9, Indian tiger; No. 10, American jaguar; No. 11, South American jaguar; No. 12, three tiger cubs, about ten months old; No. 13, Indian tiger; No. 14, Indian tiger.

There is a considerable echo in the building, and the splendid roar of the lion can now be heard in all its true grandeur.

Anthracite Coal Prices for 1876.

By a combined agreement among the anthracite coal companies, the rates for 1876 agreed upon, to consumers only, for lump, steamer, broken, and chestnut sizes, free on board, at any of the shipping ports in the vicinity of New York, are as follows:

	Lump.	Steamer.	Broken.	Chestnut.
March and April........	$4 20	$4 30	$4 40	$4 30
May........	4 25	4 35	4 45	4 35
June........	4 30	4 40	4 50	4 40
July........	4 35	4 45	4 55	4 35
August........	4 40	4 50	4 60	4 50
September........	4 45	4 55	4 65	4 55
October........	4 50	4 60	4 70	4 60
November........	4 55	4 65	4 75	4 85
December........	4 60	4 70	4 80	4 60

and at thirty-five cents per tun less free on board at Port Richmond, Pa., except for chestnut coal, which may be seventy cents per tun less than the New York free on board price: It being provided that all such contracts shall be made in writing prior to April 1, and that no commissions or allowances of any kind be made thereon, and that no such contracts be made with any other than a consumer of coal.

CAMPHORATED oil is highly recommended as a furniture polish. This is simply sweet oil in which gum camphor is dissolved. The camphor serves the additional purpose of driving away moths.