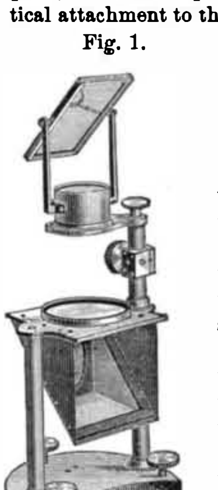
sends a thought with every stroke, has tenfold the value of one who only bestows physical strength upon his work. In the province of domestic service, every housekeeper knows that the great lack is of mental, not bodily, power. There are plenty of girls who have the requisite muscle, but few who can furnish the judgment, care, forethought, and economy which are so needful in the kitchen and the nursery. Each laborer, whatever be his sphere of action, needs to understand the laws which govern his department of labor, and so to adapt his efforts as to conform with them. If he does not, his work must be to that extent unproductive and unsuccessful. These laws, however, are so entwined with those of other branches, and so dependent upon those of life in general, that a thorough education upon a broad basis is the best preparation for any kind of labor, and a continued mental discipline the best safeguard for its success. No industry can afford to slight the intellect; no man or woman who is a mere machine can ever give out his full value to the world, no nation or community can ever emerge from indolence, except in so far as they emerge from ignorance. In this country, where the opportunities of education are so numerous and so widely spread, it would hardly seem necessary to urge their acceptance; yet it is of the highest importance to our national prosperity and personal wellbeing that we all recognize the intimate connection between the growth of intelligence and the value of labor.—*Philadelphia Ledger*.

PRODUCTION OF LIGHT FROM MECHANICAL FORCE.

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

Proceeding on the principle that nothing should be taken for granted, the lecturer began by an explanation of the properties of magnets, dwelling particularly upon those which were necessary to a correct understanding of the subject. The name magnet is derived from the name of the ancient town Magnesia, where two important minerals were found, one, white, which is employed in medicine, and the other the black magnetic oxide of iron. This latter has the remarkable property of attracting iron: remarkable because it is not confined to the ore itself but emanates from it in all directions, thus enveloping it as it were with an atmosphere of force. This was illustrated by the familiar experiment of magnetizing a bar of soft iron by bringing the lodestone near it without touching. Upon removing the lodestone, the bar no longer attracted iron. It had lost its magnetism; a steel bar would have retained it permanently. It is of the utmost consequence to understand the manner in which the force emanates from a magnet, and it has been found that it obeys the same law as the force of gravitation, namely, that it diminishes precisely as the square of the distance from the source. If we measure this force at a certain distance from the magnet in one direction, and then find points in other directions where the force is exactly the same, we obtain what is called an equipotential surface; and by repeating this process at various distances, we map out what physicists have named the magnetic field. The direction of the lines of force was beautifully shown by means of an experiment of Professor Mayer's. Iron filings were sprinkled upon a glass plate, and this was placed upon a little bar magnet in the vertical attachment to the magic lantern represented in Fig. 1, in which the light passing through the glass plate was reflected on the screen by a mirror. On slightly tapping the glass plate to give the particles of iron an opportunity of falling back upon the plate in obedience to the attraction of the magnet, they arranged themselves in symmetrical curves about the poles, forming an appearance designated as the magnetic spectrum. The particles in arranging themselves move at right angles to the lines of force. This was shown by means of a small needle suspended by a fine thread and introduced in the lantern. On gradually moving it around the magnet, it constantly changed its inclination so as always to preserve a position perpendicular to the lines of iron filings which represented the lines of attraction of the magnet.

Fig. 1.



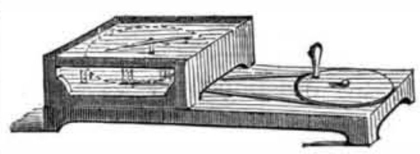
As the earth itself is a great magnet, lines of force are passing out from it in every direction, and we have the means of recognizing them. A piece of soft iron held at a certain inclination, called the magnetic dip, becomes a magnet. This dip is inclined about 73° to the vertical. By placing a magnetic needle in the lantern, it was shown that a bar of soft iron, which before had no magnetic effect on the needle, began to attract it when held near it at the requisite inclination. On holding the other end of the bar up, its polarity was reversed, as its opposite effect on the needle proved.

The similarity of the action of electricity to that of magnetism was long known without suggesting the identity of the two forces to physicists. It was reserved for Professor Oersted to discover, by accident, that a wire, in which an electrical current passed, attracted the magnetic needle. Such accidents are possible only to men of profound insight, whose powers of observation have been trained by long habits of study. It required a Newton to perceive anything extraordinary in the fall of an apple. Professor Oersted's experiment was shown by placing a magnetic needle in the lantern, surrounding it by a coil of wire, and passing a current of electricity through the latter; the needle immediately began to move. On reversing the current, the needle began to swing in the opposite direction. To answer the question whether it was really magnetism which caused the deflection of the needle, and not some other force: in other words, whether the wire carrying the current had become a real magnet: the experiment with the iron filings was repeated, substituting a wire, through which a current passed, for the small bar magnet of the first experiment. The reflection of this wire on the screen was vertical; and when the plate was tapped, the iron filings arranged themselves in horizontal lines. As in the case of the magnet, therefore, they were perpendicular to the lines of force, and it was evident that the copper wire had become a magnet, having its poles along its sides. By making a coil of the wire, we multiply the effect, because we multiply the lines of force; and this is the way to obtain the most powerful magnets. A bar of iron thrust into such a coil, as in Fig. 2, will occupy a position perpendicular to all the lines of force in it, and therefore capable of yielding the maximum effect. A diminutive piece of iron in horseshoe form surrounded by wire was then introduced in the lantern, and it attracted its armature every time a current was sent through the wire. In the next experiment the same little magnet was used with iron filings to show that the magnetic spectrum of these electro-magnets is similar to that of ordinary magnets. The immense electro-magnet of the Stevens Institute, which was mounted upon the stage, formed an amusing contrast to the little bit of iron used in the lantern.

Fig. 2.

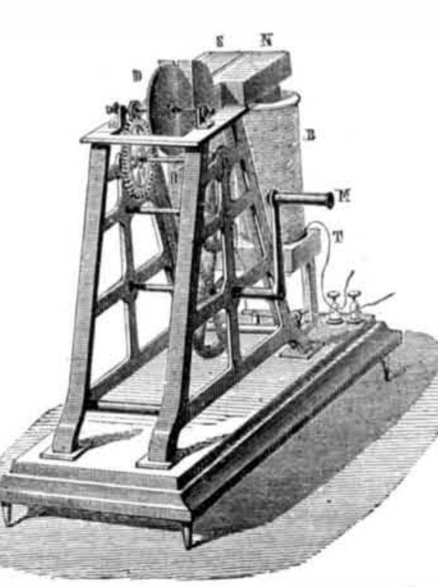
Great as was the discovery that electricity can be converted into magnetism, it must yield in importance to the one that magnetism can be converted into electricity. Arago was the first to observe that, when a copper disk is rapidly rotated under a magnetic needle, from which it is separated by a glass plate, the needle gradually begins to swing with it, following its rotation. His apparatus is represented in Fig. 3. It was left to other physicists, and especially to Faraday, to explain the phenomenon. Their conclusions may be briefly summed up in the statement that, whenever any substance capable of conducting electricity is moved across a magnetic field, a current of electricity is generated in that substance; and this current is the more powerful, the more nearly the motion is perpendicular to the lines of magnetic force. To show this fact, the large electro-magnet of the Institute was used. A wire connected with a galvanometer in the lantern was moved up and down in front of one of the poles of the magnet, so as to cut some of the lines of force proceeding from it in every direction. The effect was that every such motion caused a deflection of the needle, showing that an electrical current was generated.

Fig. 3.



An interesting experiment to illustrate the same principle was made with the apparatus represented in Fig. 4, which

Fig. 4.



consists essentially of a copper disk rotated between the poles of an electro-magnet, and therefore fulfilling the conditions of maximum effect by cutting the lines of force perpendicularly. This apparatus turned very easily by means of the crank, M, as long as the current did not pass; but the moment the connection was made, it required all the strength of the assistant to manage it. This is explained by the fact that the copper disk is magnetized, and there is a tendency of the unlike poles of the disk and the magnet to attract each other, and hence to offer resistance to further rotation. The magnetization of the disk was shown by connecting it with the needle in the lantern by means of copper wires. If the further rotation of the disk is persisted in, it becomes hot, as was shown by connecting it with a thermo-electric pile and the galvanometer in the lantern. The resistance experienced by the copper disk was excellently shown by means of another experiment of Professor Mayer's, in which a large thin copper disk was made to swing to and fro, like a pendulum, between the two poles of the large electro-magnet. The moment the current passed around the coils of the magnet, the motion of the copper disk was arrested between the poles.

If, then, we are able to obtain an electrical current by cutting the field of a magnet, we ought to be able to do the same by cutting the lines of force of the earth. This the lecturer accomplished before the audience, by moving a coil of wire, of large diameter, across the line of dip, and showing the effect on a galvanometer needle connected with the coil; every time the coil moved, an oscillation was imparted to the needle, which was distinctly visible upon the screen. The utilization of this force of the earth, like that of the sunlight for mechanical work, belongs to the future.

We have seen (in Fig. 4) the conversion of the mechanical power of the arm into heat and magnetism, and also the equivalence of magnetism and electricity. There remains the problem to turn these forces into the incomparably more subtle one of light. As in business, so in Science, it is the problem to convert raw material into high-priced products in the most economical way. A pound of cast steel of trifling value is worth thousands of dollars when converted into hair springs for watches. In the production of light, the great difficulty is to utilize our force. Even in the steam engine, only about ten per cent of the fuel is utilized as mechanical force; but when we come to light, that most imponderable of all the forces, we can scarcely utilize two per cent. When a powerful current of electricity is passed through an adequate conductor, it flows along peaceably and without unusual manifestations; but if the conductor is too thin, and it is obliged, as it were, to "crowd and elbow its way through it, it becomes red in the face, and we have the phenomenon of red heat; interrupt the conductor altogether, and make it leap over an empty space, and it becomes white in the face, emitting a brilliant light." The latter is the case in the electric lamp, Fig. 5. One of these lamps was placed upon the stage in connection with the Gramme magneto-electric machine, in which a powerful current of electricity is generated by causing the rapid revolution of one electro-magnet between the poles of several larger ones, by means of steam power derived from an engine in the basement of the Institute. This machine will be explained in the next lecture: suffice it to say, for the present, that the light obtained was equal to about 1,600 candle power. It inundated the hall with a flood of light, and illuminated the fronts of the houses on both sides of the way.

Fig. 5.

C. F. K.

Useful Recipes for the Shop, the Household, and the Farm.

A simple way of hardening small watch drills: Heat the tools in the flame of a candle and then plunge suddenly in the candle grease. This is done on account of the drills being so small that they will not retain their heat sufficiently long to enable the operator to remove them from the source of heat to a vessel containing water used for hardening.

Jewelers will find the annexed list of silver solders of considerable practical value. Hard solder: Pure silver 16 parts, copper $3\frac{1}{2}$ parts, spelter $\frac{1}{2}$ part. Medium: Fine silver 15 parts copper 4 parts, spelter 1 part. Easy solder: Fine silver 14 parts, copper $4\frac{1}{2}$ parts, spelter, $1\frac{1}{2}$ parts. Common hard solder: Fine silver, $12\frac{1}{2}$ parts, copper 6 parts, spelter $1\frac{1}{2}$ parts. Common easy solder: Fine silver $11\frac{1}{2}$ parts, copper $6\frac{1}{2}$ parts, spelter 2 parts. The fusing points of these solders are as follows: No. 1, 1,866° Fah; No. 2, 1,843°: No. 3, 1818°; No. 4, 1,826°; and No. 5, 1,802°.

The following is an iron cement which is unaffected by red heat; 4 parts by weight iron filings, 2 parts clay, 1 part fragments of Hessian crucible. Reduce to the size of rape seed and mix together, working the whole into a stiff paste with a saturated solution of salt. A piece of firebrick can be used instead of the Hessian crucible.

Böttger suggests the following process for dyeing cotton pure blue: Heat a mixture of 137 grains Paris blue, 137 grains tartaric acid, $\frac{1}{4}$ fluid oz. ammonia water, and $2\frac{1}{4}$ fluid ozs. water, and filter after cooling. Add to the deep blue filtrate a solution of caustic soda, until it is decolorised and after some time assumes a light yellow tint. Impregnate the cotton with this solution and pass it (best after allowing it to dry) through a warm, very dilute solution of sulphuric acid, and it will immediately assume a beautiful blue color and needs only to be washed in water. The sulphuric acid may be so diluted that it has scarcely a perceptibly sour taste.

The best material for hot beds is horse manure well turned and mixed with about one third its bulk of oak leaves. Another excellent mixture is the above with cotton waste, one half waste and leaves, the other half manure. The middle of March is the proper time to start the bed in northern States, and a mild day should be selected for the work. Dig a pit about 3 feet deep in front, 8 inches deeper at the back, and 6 feet wide. This affords an opportunity for adding linings if it be deemed necessary, when the heat in the bed decreases.

The Western tannin plant (*polygonum amphibium*), which grows luxuriantly in the Missouri Valley, seems destined to replace oak bark in tanning. It contains 18 per cent of tannin, while the best bark contains but 12 per cent; and large establishments employing it in Chicago find that one third more leather can be obtained with it than with a like quantity of bark. The process of tanning with it is identical with that with bark, but the leather is tougher, finer, and more durable, and receives a finer finish. The plant is an annual, and can be mowed, dried, and stacked like hay.

To prevent pumps freezing, place a small tack just under one edge of the leather valve which retains the water, sinking the tack into the leather to hold it. This will cause a small leak, and the water will not remain long enough to freeze

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