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THE RIGHI RAILROAD.

In the year 1864, the well-known geographer, Heinrich Keller, from Zurich, on ascending to the summit of the Righi Mountain, in the heart of Switzerland, discovered one of the finest panoramic displays of mountain scenery that he had ever witnessed. To his enthusiastic descriptions some lovers of nature in Zurich and Berne listened with much interest, and in the year 1865, Dr. Abel, Mr. Escher von der Luith, Aulic Councilor, Dr. Horner, and others, in connection with Keller himself, subscribed money to the amount of 2,000 marks ($500) for the purpose of building a hotel on the top of the mountain overlooking the view. This hotel was simple enough, being merely a hut such as is to be found in abundance in the Alps, and which are built by the German and Austrian Alpine Clubs. At present the old hotel is replaced by another and more comfortable building, which is rendered accessible by a railway that ascends the mountain. Mr. Riggenbach, director of the railway works at Olten, was the projector of this road, which was begun in 1869 and completed in 1871. Vitznau at Lucerne is the starting point. The ascent, which is at first gradual, soon increases one in four. After a quarter of an hour the train passes through a tunnel 240 feet in length, and over an iron bridge of the same length, by means of which the Schnurtobel, a deep gorge with picturesque waterfalls, is crossed. At Station Freibergen a beautiful mountain scene presents itself, and the eye rests upon the glittering, ice-covered ridge of the Jungfrau, the Monk, and the Eiger. Further up is station Kaltbad, where the road forks, and one branch runs to Scheideck. At about ten minutes from Kaltbad is the so-called “Kanzli” (4,770 feet), an open rotunda on a projecting rock, from which a magnificent view is obtained. The next station is Stoffelhohe, from which the railroad leads very near to the abyss on the way to Righi-Stoffel, and from this point it reaches its terminus (Righi-Kulin) in a few minutes. This is 5,905 feet above the sea, the loftiest and most northern point of the Righi group.

[Illustration: *Fig*. 1.—*Starting point of the Righi railroad*.]

[Illustration: *Fig*. 2.—*The Righi railroad*.]

The gauge of this railroad is the same as that of most ordinary ones. Between the rails runs a third broad and massive rail provided with teeth, which gear with a cogwheel under the locomotive. The train is propelled upward by steam power, while in its descent the speed is regulated by an ingenious mode of introducing atmospheric air into the cylinder. The carriage for the passengers is placed in both cases in front of the engine. The larger carriages have 54 seats, and the smaller 34. Only one is dispatched at a time. In case of accident, the train can be stopped almost instantaneously.

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[Illustration: *Fig*. 3.—*New locomotive on the Righi railroad*.]

We give herewith, from *La Lumiere Electrique*, several engravings illustrating the system. Fig. 1 shows the starting station. As may be seen on Figs. 2 and 3, the method selected for obtaining adhesion permits of ascending the steepest gradients, and that too with entire security.

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HIGH SPEED STEAM ENGINE.

The use of rapidly rotating machinery in electric lighting has created a demand for engines running from 400 to 1,200 revolutions per minute, and capable of being coupled directly to a dynamo machine. We have already illustrated several forms of these engines, and now publish engravings of another in which the most noticeable feature is the employment of separate expansion valves and very short steam passages. Many high-speed engines labor under the well-grounded suspicion of being heavy steam users, and their want of economy often precludes their employment. Mr. Chandler, the inventor of the engine illustrated above, has therefore adopted a more elaborate arrangement of valves than ordinarily obtains in engines of this class, and claims that he gains thereby an additional economy of 33 per cent. in steam. The valves are cylindrical, and are driven by independent eccentrics, the spindle of the cut-off valve passing through the center of the main valve. The upper valve is exposed to the steam on its top face, and works in a cylinder with a groove cut around its inner surface. As soon as the lower edge of the valve passes below the bottom lip of the groove, the steam is cut off from the space between it and the main valve, which is fitted with packing rings and works over a latticed port. This port opens directly into the cylinder. The exhaust takes place chiefly through a port uncovered when the piston is approaching the end of its stroke. The remaining vapor left in the cylinder is exhausted under the lower edge of the main valve, until cushioning commences, and the steam from both upper and lower ports is discharged into the exhaust box shown in Fig. 2. The speed of the engine is controlled by a centrifugal governor and an equilibrium valve. This is a “dead face” valve, and when the engine is running empty it opens and closes many times per minute. The spindle on which the valve is mounted revolves with the governor pulley, and consequently never sticks. To prevent the small gland being jammed by unequal screwing up, the pressure is applied by a loose flange which is rounded at the part which presses against the gland. The governor is adjustable while the engine is running.

[Illustration: *Improved high speed steam engine*.]

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Another economy claimed for this engine is in the use of oil. The cranks and connecting rods work in a closed chamber, the lower part of which is filled with oil and water. The oil floats in a layer on the surface of the water, and at every revolution is splashed all over the working parts, including the interior of the cylinder, which it reaches through holes in the piston. The oil is maintained exactly at one level by a very ingenious arrangement. The bottom of the crank chamber communicates through a hole, C, with an outer box, which receives the water deposited by the exhaust steam. The level of this water is exactly determined by an overflow hole, B, which allows all excess above that level to pass into an elbow of the exhaust pipe, out of which it is licked by the passing steam and carried away. Thus, as the oil is gradually used the pressure of the water in the other leg of the hydrostatic balance raises the level of the remaining portion. When a fresh supply of oil is poured into the box, it forces out some of the water and descends very nearly to the level of the hole, B.

The engine is made with either one or two cylinders, and is, of course, single-acting. The pistons and connecting rods are of forged steel and phosphor-bronze. The following is a list of their sizes:

Single Engines.

Brake Horsepower at 62 lb. Boiler Pressure.	Bore of Cylinder.	Revolutions per minute.	Height.	Floor Space.
	in.		in.	in.
21/4	4	1,100	26	14 by 14
31/2	5	1,000	28	14 " 15
6	61/2	800	30	16 " 16
10	8	700	32	18 " 18

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Double Engines.

Brake Horsepower at 62 lb. Boiler Pressure.	Bore of Cylinder.	Revolutions per minute.	Height.	Floor Space.
	in.		in.	in.
41/2	4	1,100	26	14 by 20

71/4	5	1,000	28	14 " 20
12	61/2	800	30	16 " 26
20	8	700	32	18 " 32

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The manufacturer is Mr. F.D. Bumstead, Hednesford, Staffordshire.—*Engineering*.

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THE CHINESE PUMP.

If a glass tube about three feet in length, provided at its upper extremity with a valve that opens outwardly, and at its lower with one that opens inwardly, be dipped into water and given a series of up and down motions, the water will be seen to quickly rise therein and finally spurt out at the top. The explanation of the phenomenon is very simple. Upon immersing the tube in the water it fills as far as to the external level of the liquid, and the air is expelled from the interior. If the tube be suddenly raised without removing its lower extremity from the water, the valve will close, the water will rise with the tube, and, through the velocity it has acquired, will ascend far above its preceding level. Now, upon repeating the up and down motion of the tube in the water five or six times, the tube will be filled, and will expel the liquid every time that the vertical motion occurs.

[Illustration: *The Chinese pump*.]

We speak here of a *glass* tube, because with this the phenomenon may be observed. Any tube, of course, would produce the same results.

The manufacture of the apparatus is very simple. The tube is closed above or below, according to the system one desires to adopt, by means of a perforated cork. The valve is made of a piece of kid skin, which is fixed by means of a bent pin and a brass wire (Fig. 2). It is necessary to wet the skin in order that it may work properly and form a hermetic valve. The arrangement of the lower valve necessitates the use of a tube of considerable diameter (Fig. 1).

We would advise the adoption of the arrangement shown in Fig. 2. Under such circumstances a tube half an inch in diameter and about 3 feet in length will answer very well.

It is better yet to simply use one's forefinger. The tube is taken in the right hand, as shown in Fig. 3, and the forefinger placed over the aperture. The finger should be wetted in order to perfect its adherence, and should not be pressed too hard against the mouth of the tube. It is only necessary to plunge the apparatus a few inches into the liquid and work it rapidly up and down, when the water will rise therein at every motion and spurt out of the top.

This is an easy way of constructing the *Chinese Pump*, which is found described in treatises upon hydraulics. Such a pump could not, of course, be economically used in practice on account of the friction of the column of water against a wide surface in the interior of the tube. It is necessary to consider the pistonless pump for what it is worth—an interesting experimental apparatus that any one can make for himself.—*La Nature*.

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THE WATER CLOCK.

To the Editor of the Scientific American:

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Referring to the clepsydra, or water clock, described
and illustrated in the *scientific Americansupplement* of December 20, 1884, it strikes me
that the ingenious principle embodied in that interesting
device could be put into a shape more modern and practical,
doing away with some of its defects and insuring a
greater degree of accuracy.

[Illustration: Fig 1.]

I would propose the construction given in the subjoined
sketch, *viz*.: The drum, A (Figs. 1 and 3),
is mounted in a yoke suspended in such a manner as
to bring no unnecessary, but still sufficient, pressure
on the friction roller, B, to cause it to revolve
the friction cone, C (both cone and roller being of
wood and, say, well rubbed with resin so as to increase
adhesion).

[Illustration: Fig 2.]

The friction roller should be movable (on a screw
thread), but so arranged that it can be fixed at any
point, say by a lock nut, screw, clamp, or other simple
means. It will be evident that, by shifting the
roller, a greater or less speed of the cone can be
effected, and as to the end of the cone's axis
an index hand sweeping an ordinary clock face is attached,
the speed of this index hand can be regulated to a
nicety, in proportion to that of the drum. Of
course, before fixing the size and proportion of the
disk and cone, the number of revolutions of the drum
in a given time must be ascertained by experiment.
For instance, the drum being found to make 15 revolutions
in 12 hours, the proportions would be:

Circumference of roller = 12 units.
Circumference of middle part of cone = 15 units.

Or, the drum making 21/2 revolutions in 3 hours, equal
to 9 revolutions in 12 hours:

Circumference of roller = 12 units.
Circumference of middle part of cone = 9 units.

Any slight inaccuracy can be compensated by the cone and disk device.

The drum, or cylinder, is caused to gradually revolve by a weight attached to an endless cord passing once around the drum. The latter might be varnished to prevent slipping. The weight should be provided with an automatic wedge, allowing it to be slipped along the cord in an upward direction, but preventing its descent. The weight is represented partly in section in the engraving. This weight should not be quite sufficient to revolve the drum, it being counterbalanced by the liquid raised in the chambers of the drum. The liquid, however, following its tendency to seek the lowest level, gradually runs back through the small hole, D, in the partitions, but is continually raised again, with the chamber it has just entered, by the weight slightly turning the cylinder as it (the weight) gradually gains advantage over the as gradually diminishing weight of each chamber raised.

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As to the drum, the same might be constructed as follows, *viz*.: First solder the partitions into the cylinder, making them slanting or having the direction of chords of a circle (see Fig. 2). The end disks should be dish shaped, as shown. Place them on a level surface, apply heat, and melt some mastic or good sealing wax in the same. Then adjust the cylinder part, with its partitions, allowing it to sink into the slight depth of molten matter. In this way, or perhaps by employing a solution of rubber instead of the sealing wax, the chambers will be well isolated and not liable to leak. The water is then introduced through the center openings of the disks before hermetically sealing the drum to its axis.

[Illustration: Fig. 3.]

The revolving parts of the clock being nicely balanced, a pretty accurate timepiece, I should think, would be the result. It is needless to mention that the "winding" is effected by slipping the weight to its highest point.

Of course I am far from considering the above an "instrument of precision," but would rather look upon it in the light of a contrivance, interesting, perhaps, especially to amateur mechanics, as not presenting any particular difficulties of construction.

Ed. C. *Magnus*.

Crefeld, January 5, 1885.

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NEW TORPEDO.

We illustrate a new form of self-propelling and steering torpedo, designed and patented by Mr. Richard Paulson, of Boon Hills, Langwith, Notts. That torpedoes will play an important part in the next naval war is evident from the fact that great activity is being displayed by the various governments of the world in the construction of this weapon. Our own Government also has latterly paid great attention to this subject.

The methods hitherto proposed for propelling torpedoes have been by means of carbonic acid or other compressed gas carried by the torpedoes, and by means of electricity conveyed by a conductor leading from a controlling station to electrical apparatus carried by the torpedo. The first method has, to a considerable extent, failed on account of the inefficient way in which the compressed gas was employed to propel the torpedo. The second is open to the objection that by means of telephones placed in the water or by other signaling apparatus the torpedo can be heard approaching while yet at a considerable distance, and that a quick speeded dredger, kept ready for the purpose when any attack is expected, can be run between the torpedo and the controlling station and the conductor cut and the torpedo captured. The arrangements for steering by means of an electrical conductor from a controlling station are also open to the latter objection. The torpedo we now illustrate, in elevation in Fig. 1, and in plan in Fig. 2, is designed to obviate these objections, and possesses in addition other advantages which will be enumerated in the following description.

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As stated above, the torpedo is self-propelling, the necessary energy being stored up in liquefied carbonic acid contained in a cylindrical vessel, E, carried by the torpedo. The vessel, E, communicates, by means of a small bent pipe extending nearly to its bottom, with a small chamber, B, the passage of the liquid being controlled by means of the cock or tap, F. The chamber, B, is in communication, by means of a small aperture, with the nozzle, G, of an injector, T, constructed on the ordinary principles. The liquid as it passes into the chamber, B, volatilizes, and the gas passes through the nozzle of the injector, which is surrounded by water in direct communication with the sea by means of the opening, W. The gas imparts its energy in the well-known manner to the water, being itself entirely or partially condensed, the water thus charged with carbonic acid gas being forced through the combining cone of the injector at a very high speed and pressure. Preferably the water is here divided into two streams, each driving a separate rotary motor or turbine, H, themselves driving twin screws or propellers, I. The motors exhaust into the hollow shafts, J, of the propellers, which are extended some distance beyond the propellers, so that the remaining energy of the water may be utilized to aid in propelling the torpedo on the well known principle of jet propulsion. The torpedo is preferably steered by means of the twin screws. A disk or other valve, A, is pivoted in an aperture in a diaphragm dividing the outlet of the injector, and is operated by means hereafter described, so as to diminish the stream of water on one side and increase it on the other, so that one motor, and consequently the corresponding propeller, is driven at a higher speed than the other, and so steers the torpedo.

[Illustration: PAULSON’S *self propellingand steering torpedo*.]

The valve, A, is operated automatically by the following arrangement: A mariner’s compass, P, placed in the head of the torpedo has its needle connected to one pole of a powerful battery, D. A dial of non-magnetic material marked with the points of the compass is capable of being rotated by the connections shown. This dial carries two insulated studs, *p*, each electrically connected with one terminal of the coils of an electromagnet, K, whose other terminal is connected to the other pole of the battery. These two magnets are arranged on opposite sides of an armature fixed on a lever operating the disk or valve, A. Before launching the torpedo the dial is set, so that when the torpedo is steering direct for the object to be struck, or other desired point, one end of the needle of the compass, P, is between the steeds, *p*, but contact with neither, the needle of course pointing to the magnetic north. Should the torpedo however deviate from this course, the needle makes contact with one or other of the studs according to the direction in which the

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deviation takes place, and completes the circuit through the corresponding electromagnet, which attracts the armature and causes the disk to move, so as to diminish the supply of water to one motor and increase it to the other, and so cause the torpedo to again assume the required direction. Supposing the object which it is intended that the torpedo should strike be a large mass of iron, such as an ironclad, the needle will be attracted, and, making the corresponding contact, will cause the torpedo to be steered directly away from the object. In order to prevent this, a second compass, Q, is mounted in the front of the torpedo, and when attracted by a mass of iron, it short-circuits the battery, D, and thus prevents the armature being attracted, and consequently the torpedo from deviating. This needle is also capable of slight movement in a vertical plane, so that when passing over or under a mass of iron it is attracted downward or upward, and completes a circuit by means of the stops, which operate so as to explode the charge. The charge can also be exploded in the ordinary manner, *viz*., by means of the firing pin, X, when the torpedo runs into any solid object.

The depth at which the torpedo travels below the surface of the water is regulated by means of a flexible diaphragm, M, secured in the outer casing and connected to a rod sliding freely in fixed bearings. A spiral or other spring, O, is compressed between a color on the rod and an adjustable fixed nut, by which the tension of the spring is regulated so that the pressure of water on the diaphragm, A, when the torpedo is at the desired depth just counterbalances the pressure of the spring, the diaphragm being then flush with the outer casing. The rod is connected by suitable levers to two horizontal fins, S, pivoted one on either side of the torpedo, so that they shall be in equilibrium. Should the torpedo sink too deep or rise too high, the diaphragm will be depressed or extended, and will operate on the lines so as to cause the torpedo to ascend or descend as the case may be.

In order to avoid the risk of a spent torpedo destroying a friendly vessel, a valve is arranged in any suitable part of the outer casing, and is weighted or loaded with a spring in such a manner that when under way the pressure of the water keeps the valve closed, but when it stops the valve opens and admits water to sink the torpedo.

In our description we have only given the main features of the invention, the inventor having mentioned to us, in confidence, several improvements designed to perfect the details of his invention, among which we may mention the steering arrangement and arrangements for attacking a vessel provided with what our contemporary, *Engineering*, not inaptly terms a "crinoline," *i. e.*, a network for keeping off torpedoes.
The transverse dimensions of our engravings have been considerably augmented for the sake of clearness.—*Mech. World*.

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DUPUY DE LOME.

M. Dupuy De Lome died on the 1st Feb., 1885, at the age of 68. It may be questioned whether any constructor has ever rendered greater services to the navy of any country than those rendered by M. Dupuy to the French Navy during the thirty years 1840-70. Since the fall of the Empire his connection with the naval service has been terminated, but his professional and scientific standing has been fully maintained, and his energies have found scope in the conduct of the great and growing business of the *Forges et Chantiers* Company. In him France has undoubtedly lost her greatest naval architect.

The son of a naval officer, M. Dupuy was born in October, 1816, near L'Orient, and entered *L'Ecole Polytechnique* when nineteen years of age. In that famous establishment he received the thorough preliminary training which France has so long and wisely provided for those who are to become the designers of her war-ships. After finishing his professional education, he came to England about 1842, and made a thorough study of iron shipbuilding and steam navigation, in both of which we then held a long lead of France. His report, subsequently published under the title of "Memoire sur la Construction des Batiments en Fer"—Paris, 1844—is probably the best account given to the world of the state of iron shipbuilding forty years ago: and its perusal not merely enables one to gauge the progress since made, but to form an estimate of the great ability and clear style of the writer. We may assume that this visit to England, coming after the thorough education received in Francem did much toward forming the views to which expression was soon given in designs and reports on new types of war ships.

[Illustration: M. DUPUY DE LOME.]

When the young constructor settled down to his work in the arsenal at Toulon, on his return from England, the only armed steamships in the French Navy were propelled by paddle-wheels, and there was great opposition to the introduction of steam power into line-of-battle ships. The paddle-wheel was seen to be unsuited to such large fighting vessels, and there was no confidence in the screw; while the great majority of naval officers in France, as well as in England, were averse to any decrease in sail spread. M. Dupuy had carefully studied the details of the Great Britain, which he had seen building at Bristol, and was convinced that full steam power should be given to line-of-battle ships. He grasped and held fast to this fundamental idea; and as early as the year 1845 he addressed a remarkable report to the Minister of Marine, suggesting the construction of a full-powered screw frigate, to be built with an iron hull, and protected by a belt of armor formed by several thicknesses of iron plating. This report alone would justify his claim to be considered the leading naval architect of that time; it did not bear fruit fully for some years, but its recommendations were ultimately realized.

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M. Dupuy did not stand alone in the feeling that radical changes in the construction and propulsion of ships were imminent. His colleagues in the "Genie Maritime" were impressed with the same idea: and in England, about this date, the earliest screw liners—the wonderful converted "block ships"—were ordered. This action on our part decided the French also to begin the conversion of their sailing line-of-battle ships into vessels with auxiliary steam power. But M. Dupuy conceived and carried out the bolder scheme of designing a full-powered screw liner, and in 1847 the Napoleon was ordered. Her success made the steam reconstruction of the fleets of the world a necessity. She was launched in 1850, tried in 1852, and attained a speed of nearly 14 knots an hour. During the Crimean War her performances attracted great attention, and the type she represented was largely increased in numbers. She was about 240 ft. in length, 55 ft. in breadth, and of 5,000 tons displacement, with two gun decks. In her design boldness and prudence were well combined. The good qualities of the sailing line-of-battle ships which had been secured by the genius of Sane and his colleagues were maintained; while the new conditions involved in the introduction of steam power and large coal supply were thoroughly fulfilled. The steam reconstruction had scarcely attained its full swing when the ironclad reconstructor became imperative. Here again M. Dupuy occupied a distinguished position, and realized his scheme of 1845 with certain modifications. His eminent services led to his appointment in 1857 to the highest office in the Constructive Corps—Directeur du Materiel—and his design for the earliest seagoing ironclad, La Gloire, was approved in the same year. Once started, the French pressed on the construction of their ironclads with all haste, and in the autumn of 1863 they had at sea a squadron of five ironclads, not including in this list La Gloire. It is unnecessary to trace further the progress of the race for maritime supremacy; but to the energy and great ability of M. Dupuy de Lome must be largely attributed the fact that France took, and for a long time kept, such a lead of us in ironclads. In the design of La Gloire, as is well known, he again followed the principle of utilizing known forms and dimensions as far as was consistent with modern conditions, and the Napoleon was nearly reproduced in La Gloire so far as under-water shape was concerned, but with one gun deck instead of two, and with a completely protected battery. So long as he retained office, M. Dupuy consistently adhered to this principle; but he at the same time showed himself ready to consider how best to meet the constantly growing demands for thicker armor, heavier guns, and higher speeds. It is singular, however, especially when his early enthusiasm for iron ships is remembered, to find how small a proportion of the ships added to the French Navy during his occupancy of office were built of anything but wood.

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Distinctions were showered upon him. In 1860 he was made a Councilor of State, and represented the French Admiralty in Parliament; from 1869 to 1875 he was a Deputy, and in 1877 he was elected a Life Senator. He was a member of the Academy of Sciences and of other distinguished scientific bodies. Of late his name has been little connected with ship design; but his interest in the subject was unabated.

In 1870 M. Dupuy devoted a large amount of time and thought to perfecting a system of navigable balloons, and the French Government gave him great assistance in carrying out the experiments. It does not seem, however, that any sufficient success was reached to justify further trials. The theoretical investigations on which the design was based, and the ingenuity displayed in carrying out the construction of the balloon, were worthy of M. Dupuy's high reputation. The fleet that he constructed for France has already disappeared to a great extent, and the vessels still remaining will soon fall out of service. But the name and reputation of their designer will live as long as the history of naval construction is studied.—*The Engineer*.

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THE USE OF GAS IN THE WORKSHOP.

At a recent meeting of the Manchester Association of Employers, Foremen, and Draughtsmen of the Mechanical Trades of Great Britain, an interesting lecture on "Gas for Light and Work in the Workshop" was delivered by Mr. T. Fletcher, F.C.S., of Warington.

Mr. Fletcher illustrated his remarks with a number of interesting experiments, and spoke as follows:

There are very few workshops where gas is used so profitably as it might be; and my object to-night is to make a few suggestions, which are the result of my own experience. In a large space, such as an erecting or moulder's shop, it is always desirable to have all the lights distributed about the center. Wall lights, except for bench work, are wasteful, as a large proportion of the light is absorbed by the walls, and lost. Unless the shop is draughty, it is by far the best policy to have a few large burners rather than a number of small ones. I will show you the difference in the light obtained by burning the same quantity of gas in one and in two flames. I do not need to tell you how much the difference is; you can easily see for yourselves. The additional light is not caused, as some of you may suppose, by a combined burner, as I have here a simple one, burning the same quantity of gas as the two smaller burners together; and the advantage of the simple large burner is quite as great. It is a well-known fact that the larger the gas consumption in a single flame, the higher the duty obtained for the gas burnt. There is a practical limit to this with ordinary simple burners; as when they are too large they are very sensitive to draught, and liable to unsteadiness and smoking. I have here

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a sample of a works’ pendant or pillar light, which, not including the gas supply-pipe, can be made for about a shilling. For all practical purposes I believe this light (which carries five No. 6 Bray’s union jets, and which we use as a portable light at repairs and breakdowns) is as efficient and economical a form as it is possible to make for ordinary rough work. The burners are in the best position, and the light is both powerful and quite shadowless; giving, in fact, the best light underneath the burners. It must, of course, be protected in a draughty shop; and on this protection something needs to be said.

Regenerator burners for lighting are coming into use; and, where large lights are required for long periods, no doubt they are economical. Burners of the Bower or Wenham class would be worth adopting for main street or open space lighting in important positions; but when we consider that, with the fifty-four hours’ system in workshops, artificial light is only wanted, on an average, for four hundred hours per annum, we may take it as certain that, at the present prices of regenerator burners, they are a bad investment for use in ordinary work. We must not forget that the distance of the burner from the work is a vital point of the cost question; and, for all except large spaces, requiring general illumination, a common cheap burner on a swivel joint has yet to meet with a competitor. Do not think I am old-fashioned or prejudiced in this matter. It is purely a question of figures; and my condemnation of regenerator burners applies only to the general requirements in ordinary engineering and other work shops where each man wants a light on one spot only.

Some people think that clear glass does not stop any light. This is a great mistake, as you will find it quite easy to throw a distinct shadow of a sheet of perfect glass on a white paper, as I will show you. Opal and ground glass throw a very strong shadow, and practically waste half the light. It is better to have a white enameled or whitewashed sheet-iron reflecting hood, which will protect the sides from wind, if such an arrangement suits other requirements.

I have endeavored in the engraving below to reproduce the shadows thrown by different samples of glass. This gives a fair idea of the actual loss of light involved by glass shades.

When lights are suspended, it is a common and costly fashion to put them high up. When we consider that light decreases as the square of the distance, it will be readily understood that to light, for instance, the floor of a moulding shop, a burner 6 feet from the floor will do as much work as four burners, the same size, placed 12 feet from the floor. It is therefore a most important matter that all lights should be as low as possible, consistent with the necessities of the shop, as not only is the expense enormously increased by lofty lights, but the air becomes more vitiated and unpleasant, interfering with the men's

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power of working. Any lights suspended, and, in fact, all workshop lights, must have a ball-joint or universal swivel at the point where they branch from the main, as they are liable to be knocked in all directions, and must, therefore, be free to move to prevent accidents. It is better to have wind-screens, if necessary, rather than glass lanterns, as not only does the glass stop a considerable amount of light when clean, but it is in practice constantly dirty in almost every workshop or yard.

[Illustration: PILLAR LIGHT OR PENDANT FOR WORKSHOPS.]

For bench work and machine tools, each man must have his own light under his own control; and in this matter a little attention will make a considerable saving. The burners should be union jets—*i. e.*, burners with two holes at an angle to each other—not slit or batswing, as the latter are extremely liable to partial stoppage with dust. Where batswing burners are used, I have often seen fully 90 per cent. more or less choked and unsatisfactory; whereas a union jet does not give any trouble. It is not generally known that any burner used at ordinary pressures of gas gives a much better light when it is turned over with the flat of the flame horizontal, until the flame becomes saucer-shaped, as I show you. You can see for yourselves the increase in light; and in addition to this the workman has the great advantage of a shadowless flame. In practice, a burner consuming 5 cubic feet of gas per hour with a horizontal flame is a better fitter's than an upright burner with 6 cubic feet per hour. I do not believe in the policy of giving a man a poor light to work by—it does not pay; and I never expect to get a man to work properly with smaller burners than these. We have a good governor on the main: and the lights are all worked with a low pressure of gas, to get the best possible duty. As a good practical light for a man at bench moulding, the one I have here may be taken as a fair sample. It is free to move, and the light is as near the perfect position as the necessities of the work will permit. When the light is not wanted, by simply pushing it away it turns itself down; the swivel being, in fact, a combined swivel and tap.

[Illustration: LOSS OF LIGHT BY GLASS SHADES.]

You will see on one of the lights I have here, a new swivel joint, which has been patented only within the last few days. The peculiarity of this swivel is that the body is made of two hemispheres revolving on each other in a ground joint. It will be made also with a universal movement; and its special advantage, either for gas, water, or steam, is that there is no obstruction whatever to a free passage—in fact, the way through the swivel body is larger than the way through the pipes with which it is connected. It can easily be made to stand any pressure, and if damaged by grit or dirt it can be reground with ease as often as necessary without deterioration, whereas an ordinary swivel, if damaged by grit, has to be thrown away as useless.

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[Illustration]

For meals, where a steam-kettle is not used, it is the best policy to have a cistern holding about 11/2 pints for each man, and to boil this with a gas-burner. The lighting of the burner at a specified time may be deputed to a boy. If the men’s dinners have to be heated, it is easy to purchase ovens which will do all the work required by gas at a much cheaper rate than by coal, if we consider the labor and attention necessary with any coal fire. Not that gas is cheaper than coal; but say we have 100 dinners to warm. This can be done in a gas-oven in about 20 minutes, at a cost for gas of less than 1d.; in fact, for one-fourth the cost of labor only in attending to a coal fire, without considering the cost of wood or coals. Gas, in many instances, is an apparently expensive fuel; but when the incidental saving in other matters is taken into consideration, I have found it exceedingly profitable for all except large or continuous work, and in many cases for this also. I only need instance wire card-making and the brazing shops of wire cable makers to show that a large and free use of gas is compatible with the strictest economy and profitable working.

Of all the tools in a workshop, nothing saves more time and worry than two or three sizes of good blowpipes and an efficient blower. I have seen in one day more work spoilt, and time lost, for want of these than would have paid for the apparatus twice over; and in almost every shop emergencies are constantly happening in which a good blowpipe will render most efficient service. Small brazing work can often be done in less time than would be consumed in going to the smith’s hearth and back again, independently of the policy of keeping a man in his own place, and to his own work. The shrinking on of collars, forging, hardening, and tempering of tools, melting lead or resin out of pipes which have been bent, and endless other odd matters, are constantly turning up;

and on these, in the absence of a blowpipe, I have often seen men spend hours instead of minutes. Things which need a blowpipe are usually most awkward to do without one; and men will go fiddling about and tumbling over each other without seeing really what they intend to do. They are content, as it all counts in the day's work; that it comes off the profits is not their concern. It will, perhaps, be new to many of you that blowpipes can easily be made in a form which admits of any special shape of flame being produced. I have made for special work—such as heating up odd shapes of forgings, brands, *etc*.—blowpipes constructed of perforated tubes formed to almost every conceivable shape; these being supplied with gas from the ordinary main and a blast of air from a Root's or foot blower. I have here an example of a straight-line blowpipe made for heating wire passed along it at a high speed. The same flame, as you no doubt will readily understand, can be made of any power and of any shape, and will work any side up; in fact,

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as a rule, a downward vertical or nearly vertical position is usually the best for any blowpipe. As an example of this class of work, I may instance the shrinking on of collars and tires, which, with suitable ring-burner and a Root's blower, could be equally heated in five minutes for shrinking on; in fact, the work could be done in less time than it would usually take to find a laborer to light a fire. When the rings vary much in size, the burners can easily be made in segments of circles. But then they are not nearly so handy, as each needs to be connected up to the gas and air supply; and it is, in practice, usually cheaper to have separate ring burners of different sizes. Of course, you will understand that a 1/2-inch gas-pipe will not supply heat enough to make a locomotive tire red hot, and that for large work a large gas supply is necessary. Our own rule for burners of this class is that the holes in the tube should be 1/8 to 1/10 inch in diameter, from 1/4 to 1/2 inch pitch; and the area of the tube must be equal to the combined area of the holes. The gas supply-pipe must not be less than half the area of the burner-tube. Those of you who wish to study this matter further will, I think, find sufficient information in my paper on "The Construction of High-Power Burners for Heating by Gas," printed in the Transactions of the Gas Institute for 1883, and in the papers on the "Use and Construction of the Blowpipe" and "The Use of Gas as a Workshop Tool."

[Illustration]

No doubt many of you have been troubled with the twisting of some special light casting, and will, perhaps, spend hours in the risky operation of bending an iron pattern so as to get a straight casting. A ladleful of lead and tin, melted in a small gas-furnace, will, in a few minutes, give you a pattern which you can bend and adjust to any required shape. It enables you to make trials to any extent, and get castings

with the utmost precision. There is also this advantage, that a soft metal pattern can be cut about and experimented with in a way which no other material admits of. Awkward patterns commence with us with plaster, wax, sheets of wet blotting paper pasted together on a shape or wood; but they almost invariably make their appearance in the foundry after being converted into soft metal by the aid of a gas-furnace.
I refer, of course, to thin, awkward, and generally difficult castings, which, under ordinary treatment, are either turned out badly or require a great amount of fitting. As an illustration of the use of this system of pattern-making, I have here two castings of my own, from patterns which, under the ordinary engineer's system, would be excessively costly and difficult to make as well as these are made.
The surface is a mass of intricate pattern work and perforations. To produce the flat original, as you see it, a small piece of the pattern is first cut, and from this a number of tin castings are made and soldered together. From this pattern, reproduced in iron for the sake of permanence, is cast the flat center plate you see. To produce the curved pattern I show you, nothing more is necessary than to bend the tin pattern on a block of the right shape, and we now get a pattern which would puzzle a good many pattern-makers of the old style.

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[Illustration]

I will now show you by a practical utilization of the well known flameless combustion, how to light a coke furnace without either paper or wood, and without disturbing the fuel, by the use of a blowpipe which for the first minute is allowed to work in the ordinary way with a flame to ignite the coke. I then pinch the gas tube to extinguish the flame, allow the gas to pass as before, and so blow a mixture of unburnt air and gas into the fuel. The enormous heat generated by the combustion of the mixture in contact with the solid fuel will be appreciable to you all, and if this blast of mixed air and gas is continued, there is hardly any limit to the temperatures which can be obtained in a furnace. I shall be able to show you the difference in temperature obtained in a furnace by an ordinary air blast, by a blowpipe flame directed into the furnace, and by the same mixture of gas and air which I use in the blowpipe being blown in and burnt in contact with the ignited coke.
In each case the air blast, both in quantity and pressure, is absolutely the same; but the roar and the intense, blinding glare produced by blowing the unburnt mixture into the furnace is unmistakable. The heat obtained in the coke furnace I am using, in less than ten minutes, is greater than any known crucible would stand.
I am informed that this system of air and gas or air and petroleum vapor blast, first discovered and published by myself in a work on metallurgy issued in 1881, is now becoming largely used for commercial purposes on the Continent, not only on account of the enormous increase in the heat, and the consequent work got out of any specified furnace, but also because the coke or solid fuel used stands much longer, and the dropping, which is so great a nuisance in crucible furnaces, is almost entirely prevented; in fact, once the furnace is started, no solid fuel is necessary, and the coke as it burns away can be replaced with lumps of broken ganister or any infusible material.
Few, if any, samples of firebrick will stand the heat

of this blast, if the system is fully utilized.
You will find it a matter of little difficulty, with this system of using gas, to melt a crucible of cast iron in an ordinary bed-room fire grate if the front bars are covered with sheet iron, with a hole (say) three inches in diameter, to admit the combined gas and air blast. The only care needed is to see that you do not melt down the firebars during the process. I will also show you how, on an ordinary table, with a small pan of broken coke and the same blowpipe, used in the way already described, you can get a good welding heat in a few minutes, starting all cold. In this case the blowpipe is simply fixed with the nozzle six inches above the coke, and the flame directed downward. As soon as the coke shows red, the gas pipe is pinched so as to blow the flame out, and the mixture of gas and air is blown from above into the coke as before. With this and a little practice, you can get a weld on a 7/8 inch round bar in 10 minutes.

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There is one use of gas which has already proved an immense service to those who, in the strictest sense, live by their wits. In a small private workshop, with the assistance of gas furnaces, blowpipes, and other gas heating appliances, it is a very easy matter to carry out important experiments privately on a practical scale. A man with an idea can readily carry out his idea without skilled assistance, and without it ever making its appearance in the works until it is an accomplished fact. How many of you have been blocked in important experiments by the tacit resistance of an old fashioned good workman, who cannot or will not see what you are driving at, and who persists in saying that what you want is not possible? The application of gas will often enable you to go over his head, and do what, if the workman had his own way, would be an impossibility. When a man is unable or unwilling to see a way out of a difficulty, a master or foreman has the power to take the law in his own hands; and when a workman has been met with this kind of a reply once or twice, he usually gives way, and does not in future attempt to dictate and teach his master his own business. In carrying out this matter, it is not necessary that a specimen of fine workmanship shall be produced. A man usually appreciates the wits which have produced what he has considered impossible. In purely experimental work I think I may fairly state that the use of gas as a fuel in the private workshop and laboratory has done incalculable service in the improvement of processes and trades, and has played an important part in insuring the success and fortunes of many hundreds of experimenters, who have brought their labors to a successful issue in cases where, in its absence, neither time nor patience would have been available. I need only to call to your mind the number of new alloys which, for almost endless different purposes, have come into use during the last eight or ten years. I think the use of small gas furnaces in private workshops and laboratories may fairly be said to have enabled the experiments on most, if not all, of these alloys to be carried out to a successful issue.

I have been asked to say something regarding gas engines. The only thing I can say is that I know very little about them. In my own works we have about 300,000 cubic feet of space, all of which requires to be heated, more or less, during the greater part of the year. For this purpose we must have a steam boiler, and having this steam, it costs little to run it first through the engine, and so obtain our power for a good part of the year practically without any cost. It would not pay, under any circumstances, to have two separate sources of power for summer and winter; and therefore the use of gas for power has never been considered.

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For irregular work and comparatively small powers, gas-engines have special and great advantages; and in this respect they may, perhaps, class with gas melting furnaces. If I wanted 1, or 10, or 20 lb. of melted metal, I could melt and make the casting in less time and with less cost than would be required to light a coke fire. There is no possible comparison in the two, as to convenience and economy; but if I wanted to melt 3 or 4 cwt. or 3 or 4 tons every day, I should not dream of using gas for the purpose, as the extra cost of gas in such a case would not be compensated by the saving in time. In commercial matters we must always consider first what is the most profitable way of going about our work; and, so far as I myself am concerned, I have always found it advantageous to expend some money annually on proving this by direct experiment. It is almost always possible to learn something, even from a failure.

I will now, with a blowpipe and small foot blower, heat a short length of locomotive boiler tube to a brazing heat on the table; and, in conclusion, will convert the table into a small foundry. I cannot cast you a flywheel for a factory engine; so will try at something smaller, and will reproduce a medallion portrait of Her Majesty, in cast iron, the original of which is silver, commonly valued at half a crown. From the time I light the furnace until I turn you out the finished casting I shall perhaps keep you eight or nine minutes. I can remember in the good old times 25 years ago, before I used gas furnaces, that it sometimes took about two hours to get a good wind furnace into condition to put the crucible in. My time in those days was not worth much; but if I valued it at 2s. 6d. per week, it would even then have been cheaper to use gas to do the same thing, irrespective of the cost of coke.

The age of gaseous fuel is commencing; and I feel daily, from the correspondence I receive, that there is a growing impression that gas is going to perform

miracles. We do not need to go mad about it; and my own precept and practice is to employ gas only where its use shows a profit, either in time or money. Many of those present know that I am as ready to totally condemn gaseous fuel where it does not pay as to advise its use where some advantage is to be gained.
You will understand that my remarks apply to coal gas only. As to producer or furnace gases, I know practically nothing, except that sometimes it pays better to burn your candle as a candle than make it into gas, and burn it as a gas afterward. The use of producer gas no doubt pays on a large scale; and things on a large scale, so far as gas is concerned, are not matters with which I have time to concern myself. The commercial use of coal gas has yet to be developed. It is in its infancy; and there are very few, if any, who have any conception of its endless uses, both for domestic and manufacturing purposes. The more general the information which

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can be given about its uses, the sooner it will find its own level, and the sooner the gas companies will appreciate the fact that their best customers are to be found among those who can use coal gas as a fuel for special work in manufacturing industries because it is profitable to use, and saves expensive labor. My own experiments with alloys of the rarer metals, which have not been concluded without profit to myself, would certainly never have been undertaken except with the use of gas furnaces, which were both practically unlimited in power and admitted of the most absolute precision in use; and I may safely say, without violating any confidence, that many of the precious stories and so-called "natural" products make their appearance in the world first in a crucible in a gas furnace.

At the conclusion of my lecture before the Institute at Leeds, on "Combustion and the Utilization of Waste Heat," Mr. Kitson, the Chairman, remarked that if he were a dreamer of dreams, he might look forward to the time when he would be growing cucumbers with the waste heat of his iron furnaces. Many wilder dreams than this have come true in the science of engineering; and the realization has brought honor and fortune to the dreamers, as you must all know. The history of engineering is full of the realization of "dreams," which have been denounced as absurdities by some of the best living authorities.

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THE GAS METER

The gas meter was invented by Clegg in 1816. Since that epoch no essential modification has been made of its structure. Fig. 1 shows the principle of the apparatus, *mnpq* is a drum movable around a horizontal axis. This is divided by partitions of peculiar form into four vessels of equal capacity, and dips into a closed water reservoir, RR'. A tube, *t*, near the axis, and the orifice of which is above the level of the water, leads the gas to be measured. This latter enters under the partition, *l'm*, of one of the buckets, and exerts an upward thrust upon it that communicates a rotary motion to the drum. The bucket, *l'mi*, closed hydraulically, rises and fills with gas until the following one comes to occupy its place above the entrance tube and fills with gas in turn. Simultaneously, as soon as the edge of each bucket emerges at *e*, the gas flows out through the opening that the water ceases to close, and escapes from the reservoir through the exit aperture, S. The gas, in continuing to traverse the system, is thus filling one bucket while the preceding one is losing its contents; so that, if the capacity of each bucket is known, the volumes of the gas discharged will likewise be known when the number of revolutions made by the drum shall have been counted. The addition of a revolution counter to the drum, then, will solve the problem.

[Illustration: THE GAS METER.]

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The instrument, as usually constructed, is shown in Figs. 2 and 3.

The reservoir, RR' contains the measuring drum, *mmmm*, movable around the horizontal axis, *aa*'. The gas enters at E, passes at S into an opening that may be closed by a valve, and is distributed through the box, BB', which communicates with the reservoir through an orifice in the partition, *hh*'. This orifice is traversed by the axle, *aa*'. The box, like the reservoir, contains water up to a certain level, *r*. Through a U-shaped tube, *lnl*', the gas passes from the box, BB', into the movable drum, sets the latter in motion, and makes its exit at S. In order to count the volume discharged, that is to say, the number of revolutions of the drum, the axle terminates at a in an endless screw which, by means of a cog wheel, moves a vertical rod that traverses the tube, *gg*, and projects from the box. As the tube, *gg*, dips into the water, it does not allow the gas to escape, and this permits of the revolution counter that the rod actuates being placed in an external case, CC'.

The counter consists of toothed wheels and pinions so arranged that if the first wheel makes one complete revolution corresponding to a discharge of 1,000 liters, the following wheel, which indicates cubic meters, shall advance one division, and that if this second wheel makes one complete revolution marked 10 cubic meters, the third, which indicates tenths, shall advance one division, and so on. Hands fixed to the axles of the wheels, and movable over dials, permit the volume of gas to be read that has traversed the counter.

The object of the other parts of the instrument are to secure regularity in its operation by keeping the level of the liquid constant. It is evident, in fact, that if the level of the water gets below *r*, the capacity of the buckets will be increased, and the counter will indicate a discharge less than is really the case, and *vice versa*. If the level descends as far as to the orifice in the partition, *hh'*, the gas will flow out without causing the apparatus to move. The water is introduced into the counter through *f*, which is closed with a screw cap, and passes through the opening shown by dotted lines into the reservoir, RR', whence it flows to the box, BB', When it has reached the desired level, it gains the orifice, *r*, of a waste pipe, escapes through the siphon, *ruv*, and makes its exit through the aperture, *b'*, when the screw cap of the latter is removed. If, by accident, the level of the water should fall below a certain limit, a float, *f*, which follows its every movement, would close the valve, *s*, and stop the flow of the gas. Finally a tube, *tt'* soldered to the lower part of the tube, *lnl'*, and dipping into the water of a compartment, P, serves to allow the surplus water to flow out at *b'*. To prevent the apparatus from being disarranged upon the drum being revolved in the opposite direction, there is fixed to the axle, *aa'*, a cam which lifts a click, *z*, when the rotation is regular, but which is arrested by it when the contrary is the case.—*Science et Nature*.

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DOBSON AND BARLOW’S IMPROVEMENTS IN HEILMANN’S COMBERS.

Next to the mule, there is no doubt that the most beautiful machine used in the cotton trade is Heilmann’s comber. Although the details of this machine are hard to master, when once its action is understood it will be found to be really simple. The object of combing is to remove the short staples and the dirt left in after the carding of the cotton, such as is used in the spinning of fine and even coarse numbers. The operation is an extremely delicate one, and its successful realization is a good illustration of what is possible with machinery. Combing machines are usually made with six heads, and sometimes with eight. As the working of each head is identical, we only speak of one of them. By means of a pair of fluted feeding rollers a narrow lap, about 71/2 in. wide, is passed into the head, in which the following action takes place: Assuming that the stroke is finished, the lap is seized near its end by a pair of nippers, so as to leave about half the length of the staple projecting. These projecting fibers are combed by a revolving cylinder, partially covered with comb teeth. When the front or projecting ends of the fibers are thus combed, a straight comb in front of the nippers drops into them, the nippers open, and the fibers are drawn through the straight comb. This combs the tail ends, and at the same time the fibers, now completely combed, are placed on or pieced to the fibers that had been combed in the previous stroke, producing in this way a continuous fleece of combed cotton. In short, in this most striking operation, the fiber during the combing is completely detached from the ribbon lap, carried over, and pieced to the tail end of the combed fleece, for a moment having no connection with either. Since the expiry of the patent, Messrs. Bobson and Barlow, of Bolton, have constructed a great many of these machines, and have found that, as compared with the original make, it was possible to greatly increase their efficiency. They accordingly devoted much attention to this object, and have patents for several improvements. To describe these so as to be understood by everybody would be a most difficult task, and would take more space than we can afford. We simply wish to record what these improvements are, and will suppose we are writing for those who have a good acquaintance with Heilmann's comber.

[Illustration: DOBSON AND BARLOW'S IMPROVEMENTS IN HEILMANN'S COMBERS.]

We give herewith a perspective view of the improved machine. On examination it will be noticed that an alteration is made in the motion seen at the end of the machine for working the detached rollers. This alteration we believe to be a decided improvement over Heilmann's original arrangement. It dispenses with the large detaching cam, the cradle, the notch-wheel, the catch and its spring, the large

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spur wheel which drives the calender roller, and the internal wheels for the detaching roller-shaft, substituting in their stead a much simpler motion, consisting of a smaller cam, a quadrant, and a clutch. The arrangement, having fewer parts, is also much more compact than the old one, for with the driving pulleys in the best position it enables the machine outside the framing to be shortened 10 in., an important point in a room full of combers. The action of this detaching motion is positive, and enables the machine to be run at a high speed without danger of missing, as happens when the point of the catch for the old notch-wheel becomes broken or worn away. Another important feature of the new arrangement is that it allows the motion of the detaching-roller to be varied. By an adjustment, easily made in a few seconds, the delivery may be altered to suit different classes of cotton or kinds of work without the necessity of changing the cams or the notch-wheels.

An improvement has been made in the construction of the nippers. In the ordinary Heilmann's comber, the upper blade has a groove in its nipping edge, and the cushion plate is covered with cloth and leather, the fibers being held by the grip between the leather of the cushion plate and the edges of the groove in the upper blade, or knife, as it is called. The objections to this mode of construction were that the leather on the cushion plate required frequent renewing, and unless the adjustment was more accurate than could always be relied on, the grip of the nippers was not perfect, for while at one end the nipper might be closed, at the other end it might be open wide enough to allow the cotton to be pulled through by the combing cylinder, and made into waste. In Messrs. Dobson and Barlow's nipper there is neither cloth nor leather on the cushion plate. Its edge is made into a blunt ^, upon which the narrow flat surface of a strip of India rubber or leather fixed in the knife falls to give the nip. By this plan the cushion is applied to the knife instead of to the plate, which of course makes the cushion plate, after it has once been set, a fixture; it also dispenses with the accurate setting, as is now necessary in the old arrangement. It further does away with the frequent and expensive covering of the cushion-plate with roller leather and cloth, thus effecting a considerable saving, not only in cost of material, but also in labor, inasmuch as the nipper knives can be taken off, recovered, and replaced in one-sixth the time required to cover the cushion plates and replace them on the old system. American cotton of 7/8” staple to silk of 21/2” staple can also be combed by this improved arrangement, an achievement which has been attempted by many, but hitherto without arriving at any success. Messrs. Dobson and Barlow have however overcome the difficulty by their improvements, which combine three important qualities, *viz*., simplicity, perfection, and cheapness. Many hundreds

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of other makers' machines have been altered to their new arrangements. The cam for working the nipper has also been altered to give a smoother motion than usual; one that moves the nipper quietly and without jerks when the machine runs from 80 to 95 strokes per minute. A very decided improvement has been made in the construction of the combing cylinder. The combs are always fixed on a piece called the "half-lap," which, in its turn, is secured to a barrel called the "comb-stock." Now it is very desirable and important that these half-laps should be perfectly true and exactly interchangeable. When one half-lap is taken off for repairs, another half-lap must be ready to take its place on the cylinder. The original mode in which the cylinders were made rendered it a matter of mechanical difficulty—almost an impossibility in the machine shop—to produce them exactly alike. To avoid this difficulty, Messrs. Dobson and Barlow have reconstructed the combing cylinder, and the parts being fitted together by simple turning or boring, accuracy and interchangeability can always be depended upon. The screws which fasten the cylinder to the shaft are also cased up with the cylinder tins, thus avoiding any accumulation of fly on the screw heads.

The motion for working the top detaching, the leather, or the piecing roller, as it is variously called, has also been improved. The ends of this roller are always carried on the top of two levers that are oscillated by a connecting rod attached to their bottom ends. In the new motion the connecting rod is dispensed with, and one joint saved. The joint that remains is at the foot of the levers that carry the leather roller. This joint is constructed so that it may be easily altered, and by its means one of the most delicate settings of the combing machine, *viz*., that of the leather roller, may be made with greater readiness than with the old system. Further, from the mode of mounting these rollers another advantage is gained in the facility of setting them.

In setting with the old arrangement, only one end of the roller is adjusted at a time; in the new, the adjustment sets the ends of two rollers. With regard to the leather roller also, it was found that as the round brass tubes in which its ends revolved had very little wearing surface, they got worn into flats on the outside, and thus worked inaccurately. In the machine under notice this defect is remedied. The tubes are made square on the outside, and having ample bearing surface they keep their adjustment perfectly.

On the top of the detaching roller is a large steel fluted roller carried at each end by a small arm called a “horse tail.” In the original machine this roller simply kept its place upon the detaching roller by its weight, and when the machine came to be run at high speeds it was found that owing to its lightness the contact thus obtained was not reliable, the flutes or ribs of the roller slipping upon those

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of the detaching roller, which for good work is undesirable. This is remedied by placing a heavier top roller in the horse tails, which is made with a broader bearing so as to give greater solidity to the top roller. Another good idea we noticed in this machine was in the application of a treble brush carrier wheel, which permits of the brushes being driven at three different speeds as they become worn. For instance, when the brushes are new the bristles are long, and consequently they are not required to revolve as quickly as when the bristles are far worn. By this improvement the brush lasts considerably longer than in any other system of machine. Their speed can also be regulated according to the length of the bristles, and the change from one speed to the other can be effected in a very few minutes.

A common defect in combing machines is the flocking that frequently happens. This is the filling up of the combs on the cylinder with dirt and cotton, which the brush fails to remove. Although in general appearance the cleaning apparatus is the same as the ordinary one, modifications are introduced which make its action always effective and reliable. We were informed by a mill manager, who has a great number of these combers, that he meets with no inconvenience from flocking from one week end to another. Altogether, it will be seen that Messrs. Dobson and Barlow have almost reconstructed the machine, strengthening and improving those parts which experience showed it was necessary to modify. As a result their improved machine works at a high speed (80 to 95 strokes per minute, according to the class of cotton), with great smoothness and without noise, and from the almost complete absense of vibration the risk of breakages is reduced to a minimum.—*Textile Manufacturer*.

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THE MUNICIPAL SCHOOL FOR INSTRUCTION IN WATCH-MAKING, AT GENEVA.

When, in 1587, Charles Cusin, of Autun, settled at Geneva and introduced the manufacture of watches there, he had no idea of the extraordinary development that this new industry was to assume. At the end of the seventeenth century this city already contained a hundred master watch makers and eighty master jewelers, and the products of her manufactures soon became known and appreciated by the whole world.

The French revolution arrested this impetus, but the entrance of the Canton of Geneva into the Confederation in 1814, rendered commerce, the arts, and the industries somewhat active, and watch-making soon saw a new era of prosperity dawning.

On the 13th of Feb., 1824, at the instigation of a few devoted citizens, the industrial section of the Society of Arts adopted the resolution to form a watch-making school, which, having been created by private initiative, was only sustained through considerable sacrifices.

[Illustration: CLASS IN ESCAPEMENTS AT THE WATCH MAKING SCHOOL, GENEVA.]

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In 1840 the school was transferred to the granary building belonging to the city. In 1842, when it contained about fifty pupils, it was made over to the administrative council of the city by the committee of the Society of Arts. From 1824 to 1842 the school had given instruction to about two hundred pupils. From 1843 to 1879 it was frequented by nearly eight hundred pupils, two-thirds of whom were Genevans, and the other third Swiss of other cantons and foreigners.

The school, then, has furnished the watch-making industry with the respectable number of a thousand workmen, among whom large numbers have been, or are yet, distinguished artists.

The rooms of the granary, where the school remained for nearly forty years, became inadequate, despite the successive additions that had been made to them, and it became necessary to completely transform them. The magnificent legacy that the city owes to the munificence of the Duke of Brunswick was partly employed in the reorganization, and the school is now located in a vast building designed to answer the requirements of instruction. This structure, which is located in Necker Street, presents an imposing and severe aspect. The main building embraces most of the workshops, the office, the library, and the classroom for instruction in mechanics, all of which receive a direct light. At right angles with the main building are two wings. The one to the north contains in its three upper stories workshops occupied by classes in escapements, bezil setting, compensating balances, and ruby working. On the ground floor are installed juvenile schools.

The south wing contains halls for lectures on theory, and two workshops looking toward the north. The ground floor is used for the same purpose as that of the north wing.

Finally, in the center of the main building is a wing parallel with its two mates. It is in this that is located the vast staircase that leads to spacious landings at which ends on every story a large corridor common to all the halls and workshops. It is in this part of the building that we find the amphitheater of physics and chemistry and the laboratories. Here also is located the museum in course of formation (gotten up in view of the historical study of watch-making), and the amphitheater designed for certain public lecture courses.

In the way of heating and lighting all parts of the building nothing has been neglected, and special care has been taken to have the ventilation perfect.

At present the instruction comprises a practical and a theoretical course.

Practical Instruction.—This is divided into three sections: (1) an elementary one having in view the construction of the simple watch in its essential parts; (2) a higher section in which the pupils learn to recognize the complicated parts; and (3) a section of mechanics applied to watch-making and to the study of the construction of machines and tools for facilitating and improving the manufacture.

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1. *Elementary Section, First Year*.—The pupil must manufacture all the small tools necessary for making unfinished movements; that is, drills, reamers, punches, files, *etc*. He must then learn to file and turn, and to make use of the finishing lathe with the bow, or of the foot lathe.

In general, the time taken by an apprentice to manufacture his tools is from two to three months, and he can scarcely go to work on the movements before this.

In this class the regular pupils have to execute seven pieces of work in the rough, two for horizontal escapements with key and regulating wheel, and five for various other escapements. Among these there is one for simple repetition and one for minute piece. Aside from the work fixed by the programme, the pupils may manufacture all the other complicated pieces upon obtaining the authority for it from their masters and the director.

The average time employed in performing the work imposed by the programme necessarily depends upon the capacity of the pupil, but we may say that in general ten months are necessary.

Second Year.—After executing his last piece of work in a satisfactory manner, the apprentice passes into the class in regulators, where he begins to manufacture the small tools that he will require.

In this work, as in the preceding, he must take all his pieces from the crude metal, and he must do the forging himself, as well as the roughing down, the turning, filing, and shaping, and finally the finishing, without the aid of any other machine than the dividing one.

In general, after eighteen months of work, the apprentice goes to the finishing shop, where the delicate and minute work begins, pivoting, putting the wheels in place, and practical study of gearings. After learning how to divide a wheel correctly, he is set to work on pinions and wheels in the rough, which he must rivet, finish, and pivot according to the different planes of the pieces that have been calculated and executed by him under the direction of the master.

The programme to be followed by the pupils of the class in finishing is, as regards number of pieces, the same as that of the preceding classes, that is to say, seven.

In general, the pupil passes from the class in finishing to the class in dial-trains, where he makes two of these for his pieces—one a simple and the other a minute train. The teaching of this part is very important as regards the manufacture of escapements. In constructing the dial train, the pupil perfects his filing and learns to make the adjustments correct.

The last class in the elementary instruction is the one in escapements (Fig. 1), the programme of which includes several distinct parts: (1) The tools that are strictly necessary; (2) escapement and cylinder adjustment; (3) making the compensating balances for the pupil's pieces; (4) pivoting, putting in place, and finishing the escapements in regulating pieces. Here, as in the preceding classes, the pupils must do all the work themselves. During their stay in the elementary classes the work done is submitted to the director, who examines it and sends it back to the instructors accompanied with a bulletin containing his estimate as to its value, and his observations if there is occasion to make any.

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Pupils who cannot or who do not wish to go over the entire field of the programme stop here, and are now capable of earning their living and of lightening the load that oppresses their parents.—*Science et Nature*.

* * * * *

MACHINE FOR POLISHING BOOTS AND SHOES.

The principle of an apparatus for blackening boots and shoes dates back to 1838, the epoch at which a machine of this kind was put into use at the Polytechnic School. Since then it seems that not many applications have been made of it, notwithstanding the services that a machine of this kind is capable of rendering in barracks, lyceums, hotels, *etc*. Mr. Audoye, an inventor, has recently taken up the question again, and has proposed to The Societe d'Encouragement a model that gives a practical solution of it. The use of this will allow a notable saving in time and trouble to be effected.

This brush (see engraving) revolves around a horizontal axle supported by a cast iron frame similar to that of a sewing machine. Motion is communicated to it by a double pedal, which actuates a connecting rod and a system of pulleys. The external surface of the brush contains three channels in which the foot gear to be polished is successively placed. In the first of these the dust and mud are removed, in the second the blacking is spread on, and in the third the final polish is obtained.

[Illustration: MACHINE FOR POLISHING BOOTS AND SHOES.]

In order to guide the blacking to that part of the brush which is to receive it, Mr. Audoye protects the lower part of the latter by a half-cylinder of sheet iron. On this there is placed a vessel containing the blacking, and into which dips a copper cylinder having a grooved surface. The horizontal axis of this cylinder is movable; when at rest it is so placed that the cylinder is an inch or so below the brush, but when the operator pulls a button that is within reach of his left hand, the axis is lifted, a contact takes place between the brush and the cylinder, and the former is thus given a rotary motion. As the cylinder still continues to dip into the blacking, the latter is thus spread ever the brush.—*La Genie Civil*.

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PERSONAL SAFETY WITH THE ELECTRIC CURRENTS.

To the Editor of the Scientific American:

In your paper of the 21st of February there is an article on personal safety with electric currents, by Prof. A.E. Dolbear. He says that a Holtz machine may give through a short wire a very strong current. For if E = 50,000 volts, R = 0.001 ohm, then C = 50000/0.001 = 50,000,000 amperes. Now that is a very large quantity of electricity, and is equal to an enormous horse power. I think the person receiving that charge would not need another. According to Ohm's law, the strength of current

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is proportional to the electromotive force divided by the total resistance, external and internal. The last is a very important element in the Holtz machine, and will make a big difference in the current strength. Here are some of the results obtained from experiments made with the Holtz machine. A machine with a plate 46 in. in diameter, making 5 turns in 3 seconds, produced a constant current capable of decomposing 31/2 millionths of a milligram in a second. This is equal to the effect produced by a Grove's cell in a circuit of 45,000 ohms resistance. The current produced would be about 0.0000044 ampere. That is rather small compared with the Professor's result. Rossetti found that the current is nearly proportional to the velocity of rotation. It increases a little faster than the velocity.

The electromotive force and resistance is constant if the velocity is constant. The electromotive force is independent of the velocity, but diminishes as the moisture increases, and is about equal to 52,000 Daniell cells. The resistance when making 120 revolutions per minute is 2,810 million ohms. At 450 per minute, 646 million.

Taking it at 450, C = 53950/64600000.001 = 0.0000835 ampere, against the Professor's 50,000,000, amperes, and it would be equal to about 0.006 horse power, which I think would be the more correct of the two; calling E equal to 50,000 Daniell cells.

Yours, Respectfully,

E. ELLSWORTH.

Portland, Me., March 5, 1885.

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A VISIT TO CANADA AND THE UNITED STATES IN THE YEAR 1884.

[Footnote: A lecture delivered before the Society of Telegraph Engineers and Electricians, London, Dec. 11, 1884.]

By Mr. W.H. PREECE, F.R.S.

I do not know what the sensations of a man can be who is about to undergo the painful operation of execution; but I am inclined to think his sensations must be somewhat similar to those of a lecturer, brimful of notes, who has to wait until the clock strikes before he is allowed to address his audience.

The President has been kind enough to refer to the paper I propose to give you, as “Electricity in America in the year 1884;” but I would rather, after having thought more about it, that it be called “A Visit to Canada and the United States in the year 1884.”

It will be in the recollection of a good many who are present that in the year 1877 I visited America, in conjunction with Mr. H.C. Fischer, the Controller of our Central Telegraph Station, to officially inspect and report upon the telegraph arrangements of that country; and on the 9th February, 1878, I had the pleasure of communicating to the members of this Society my experiences of that visit.

During the present year my visit was not an official one; I went for a holiday, and specially to accompany the members of the British Association, who, for the first time in the history of that association, held a meeting outside the limits of the United Kingdom.

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We sailed from Liverpool in a splendid steamship called the Parisian. There were nearly 200 B.A. members on board; and notwithstanding the fact that rude Boreas tried all he could to prevent us from reaching the other side of the Atlantic; notwithstanding the fact that the Atlantic expressed its anger in the most unmistakable terms at our audacity in turning from our native shore; notwithstanding the fact that Greenland's icy mountains blew chilly blasts upon us, and made us call out all the warm things we possessed—I say notwithstanding all this, we reached the Gulf of St. Lawrence in safety, and I do not think that a merrier or a happier crew ever crossed the Atlantic.

There is one very interesting fact that is not generally known, and I certainly was unaware of it before I started, in connection with this particular route across the Atlantic, and that is, that by it the ship passes within only 200 miles of Greenland. The great circle that directs the shortest route from the north of Ireland to the Straits of Belle Isle passes within the cold region, and hence, while you were all sweltering in heat in London, we were compelled to bring out our ulsters and all our warm garments, to enable us to cross with any degree of comfort. The advantage of this particular route is supposed to be the fact that only five days are spent upon the ocean, and the remainder of the voyage is occupied in the calms and comforts of the Gulf and River St. Lawrence. But I am inclined to think that the roughness of the ocean and the coolness of the weather at all seasons are quite sufficient to prevent anybody from repeating our experience.

We arrived at Montreal in time to attend the opening meeting of the British Association; and at Montreal we were received with great hospitality, great attention, and great kindness from all our brethren in Canada, and we held there certainly a very successful and very pleasant gathering. There were 1,773 members of the British Association altogether present, and of that number there were 600 who had crossed the Atlantic; the remainder being made up of Canadians, and by at least 200 Americans, including all the most distinguished professors who adorn the rolls of science in the United States. As is invariably the rule in these British Association meetings, we had not only papers to enlighten us, but entertainments to cheer us; and excursions were arranged in every direction, to enable us to become acquainted with the beauties and peculiarities of the American continent. Some members went to Quebec, some to Ottawa, others to the Lakes, others to Toronto, many went to Niagara; and altogether the arrangements made for our comfort and pleasure were such, that I have not heard one single soul who attended this meeting at Montreal express the slightest regret that he crossed the Atlantic.

The meeting at Montreal certainly cannot be called an electricians' meeting. The gathering of the British Association has often been distinguished by the first appearance of some new instrument or the divulgence of some new scientific secret; but there was nothing of any special interest brought forward on this occasion. The only real novelty or striking fact that I can recall as having taken place was a remarkable discussion that originated by Professor Oliver Lodge, upon the "Seat of the Electromotive Force in a Voltaic Cell."

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This was an experiment on the part of the British Association. Discussions, as a rule, have not been the case at our meetings. Papers have been read and papers have been discussed; but on this occasion three or four subjects were named as fit for discussion, and distinguished professors were selected to open the discussion.

On this particular subject, Professor Oliver Lodge opened the discussion, and he did so in an original, an efficient, and in a chirpy kind of manner that took by storm not only the professors who knew him, but those who did not know him; and I am bound to say that I do not think we could possibly better spend an evening during the coming session, or more profitably, than by asking Professor Oliver Lodge to bring the subject before this Society, so as to allow us on this side of the water to discuss the same subject.

Of course the prominent figure at our meetings was Lord Rayleigh; and I do not think that any person could possibly have been present at those meetings of the British Association without feeling an intense personal admiration for this man, and an affection for the way in which he maintained the position of an English gentleman and the credit of an English scientific body, to the astonishment and delight of every one present. Then, again, we had our past President, Sir William Thomson, who was not quite so ubiquitous as usual; he did not dance from section to section as he usually does, but remained as president of his own section, A. I think he only left his section for a day, and that was to attend the electrical day in Section G; but in his own section he brought down those words of wisdom that one always hears from him, and which make one always regret that there is not always present about him a shorthand writer to take down thoughts and ideas that never occur again, and are only heard by those who have the benefit of being present.

The subjects brought forward were not of intense interest. We had a paper by Dr. Traill, describing the Portrush Railway, and there were various other papers; and I can pass over some of the other subjects, because I shall have to deal with them under another head. But while we were in Montreal, a deputation of American professors and members of the American Association came over, and invited a good many of those who were present at Montreal to visit the American Association at Philadelphia. I was one of those who went over to America simply and solely for a holiday, and I am bound to say that I set my face determinedly against going to Philadelphia. I traveled with two charming companions, and we all decided not to go to Philadelphia. But the compact was broken, and we capitulated, and went from the charming climate of Montreal into the most intense heat and into the greatest discomfort that I think poor members of the Telegraph Engineers' Society ever experienced. We entered a heat that was 100 deg. by day and 98 deg. by night; and I do not think there is anybody in this room, unless he has been brought up in the furnace-room of an Atlantic steamer, who can fully appreciate the heat of Philadelphia in these summer months. The discomforts of the climate were, however, amply compensated for by the hospitality and kindness of the inhabitants. We spent, in spite of the heat, a very pleasant time.

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Before referring further to the meetings at Philadelphia, I may just mention the other journeys that I took. My holiday having been broken by the rupture of the union to which I have alluded, I had to devote it then to other purposes, and, in addition to Montreal and Philadelphia, I went to New York (to which I shall refer again), from New York to Buffalo, then to Lake Erie and Cleveland, and on to Chicago, where I spent a week or more. From Chicago I went to see the great artery of the West—the Mississippi. I stopped for a day or two at St. Louis. One remarkable fact came to my knowledge, and I dare say it is new to many present, and that is, that the Mississippi, unlike other rivers, runs uphill. It happens, rather curiously, that, owing to the earth being an oblate spheroid, the difference between the source of the Mississippi and the center of the earth is less than that of its mouth and the center of the earth, and you may see how this running up hill is accounted for.

From St. Louis I went to Indianapolis, thence to Pittsburg, where they have struck most extraordinary wells of natural gas. Borings are made in the earth from the crust to a depth of 600 or 700 feet, when large reservoirs of natural gas are "struck." The town is lighted by this gas, and it is also employed for motive power. In Cleveland, also, this natural gas is found, and there is no doubt that it is going to economize the cost of production very much in that part of the country. From Pittsburg I went to Baltimore, where Sir William Thomson was occupied in delivering lectures to the students of the Johns Hopkins University. In all these American towns one very curious feature is that they all have great educational establishments, endowed and formed by private munificence. In Canada there is the McGill University, and in nearly every place one goes to there is a university, like the Johns Hopkins at Baltimore, where Johns Hopkins left 3,500,000 dollars to be devoted entirely to educational purposes; and that university is under the management of one of the most enlightened men in America, Professor Grillman, and he has as his lieutenants Professors Rowland, Mendenhall, and other well-known men, and each professor is in his own line particularly eminent. Sir William Thomson delivered there a really splendid course of lectures. From Baltimore I went through Philadelphia to Boston. I visited Long Branch, and I spent a long time in New York, so that from what I have said you will gather that I spent a good deal of my time in the States. Wherever I went I devoted all my leisure time to inquiry into the telegraphic, telephonic, and electric light arrangements in existence. I visited all the manufactories I could get to, and I did all I possibly could to enable me to return home and afford information, and perhaps amusement, to my fellow-members of this Society.

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As an illustration of the intense heat we experienced, I may mention that it was at one time perfectly impossible to make the thermometer budge. The temperature of the blood is about 97 or 98 degrees, and if the temperature of the air be below the temperature of the blood, of course when the hand is applied to the thermometer the mercury rises. In one of our journeys up the Pennsylvania Road we tried to make the thermometer budge as usual, but could not, which proved that the temperature of the air inside the Pullman car in which we traveled was the same as that of the blood.

The American Association is of course based on the British Association. Its mode of administration is a little different. It is divided into sections, as is the British Association, but the sections are not called the same. For instance, in the British Association, Section A is devoted entirely to physics, but in the American Association, Section A is devoted to astronomy and Section B to physics. In the British Association, Section G is devoted to mechanics, but in America Section D is devoted to that subject. But with the exception of just a change in the names of some sections which are familiar as household words to members of the British Association, the proceedings of the American Association do not differ very much from ours. They have, however, one very sensible rule. The length of every paper is indicated upon the programme of the day's proceedings, and the continuation or the stopping of any discussion on that paper is in the hands of the section. For instance, if the President thinks that a man is speaking too long, he has only to say, "Does the meeting wish that this discussion shall be continued, or shall it be stopped?" A majority on the show of hands decides. Such a practice has a very wholesome effect in checking discussion, and I certainly think that some of our societies would do well to adopt a rule of the same character.

The meeting of the American Association, again, was not distinguished by any particular electrical paper, or any new electrical subject. The main subject that was brought before us was the peculiar effect called “Hall’s effect,” that Professor Hall, now of Harvard College, and then assistant to Professor Rowland, discovered in the powerful field of a magnet when a current was passed through a conductor; and a description of that effect (which he at one time thought was an indication that electricity was something separate from matter) formed the subject of two debates that lasted for nearly the whole of two days. I am bound to say that in that prolonged discussion the members of this Society held their own. I see two very prominent members present who spoke on most of the electrical subjects dealt with—Professor G. Forbes, who knows what he says and says what he knows, and Professor Silvanus Thompson, who held his own under very trying circumstances.

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At the same time that this meeting of the American Association was being held at Philadelphia, where we were treated with marvelous hospitality,—excursions, soirees, dinners, parties, *etc*., *etc*.—and as though it were not quite sufficient to bring over humble Britishers from this side of the Atlantic to suffer the intense heat at one meeting of the Association, they held at the same time an Electrical Conference. There was a conference of electricians appointed by the United States Government, that was chiefly distinguished on the part of the American Government by selecting those who were not electricians. But many attended the Electrical Conference who stand high as electricians, one especially, who, though perhaps from want of experience he did not shine very brilliantly as a chairman, certainly stands as one of the ablest electricians of the day—I mean Professor Rowland. The Conference was held under Professor Rowland's presidency, and nearly all the well-known professors of the United States attended. The Conference was established by the United States Government to take into consideration the results and conclusions arrived at by the Congress of 1884, held in Paris. The Paris Congress decided upon adopting certain units of resistance of electromotive force, of current, and of quantity, and they determined the particular length of a column of mercury that should represent the ohm—a column of mercury 106 centimeters long and of one square millimeter in section. It was necessary that the United States should join this Conference, so a commission was appointed to consider the whole matter. All these units were brought before them, as well as the other conclusions of the Paris Congress, such as the proper mode of recording earth currents and atmospheric electricity. The Paris units were adopted in face of the fact that the length determined upon at Paris was not the length that Professor Rowland himself had found as that which should represent the ohm. It differed by about 0.2, as near as I can remember; but it was thought so necessary that uniformity and unanimity should exist all over the world in the adoption of a proper unit, that all differences were laid aside, and the Americans agreed to comply with the resolutions of the Paris Congress.

There were two units that I had the temerity to bring forward, first, at the British Association, and secondly, before the Electrical Conference. It will be remembered, that at the meeting of the British Association at Southampton in 1882, the late Sir W. Siemens proposed that the unit of power should be the watt, and that the watt, which was derived from the C.G.S. system of absolute units, should in future, among electricians, be the unit of power. This was accepted by the British Association at Montreal, and it was also accepted by the American Electrical Conference at Philadelphia. But I also, at Montreal, suggested that as the watt was the unit of power, so we ought to make some multiple

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of that unit the higher unit of power, comparable to that which is now represented by the well-known term “horsepower.” Horsepower, unfortunately, does not form itself directly into the C.G.S. system. The term horsepower is a meaningless quantity; it is not a horsepower at all. It was established by the great Watt, who determined that the average power exerted by a horse was equal to about 22,000 foot pounds raised per minute; but this was thought by him to be too little, so he increased it by 50 per cent., and so arrived at what is the present horsepower, 33,000 foot pounds raised per minute. Foot pounds bear no relation to our C.G.S. system of units, and it is most desirable that we should have some unit of power, somewhere about the horsepower, to enable us to convert at once watts into horsepower. For that purpose I proposed that 1,000 watts, or the kilowatt, should replace what is now called the horsepower, and suggested it for the consideration of engineers. It has been received with a great deal of consideration by those who understand the subject, and a considerable amount of ridicule by those who do not. It is rather a remarkable thing that, as a rule, one will always find ridicule and ignorance running side by side; and it is an almost invariable fact that when a new proposition is brought forward, it is laughed at. I am always very glad to see that, because it always succeeds in drawing attention to the matter. I remember a friend of mine, who had written a book, being in great glee because it was severely criticised by the *Athenaeum*, a fact which drew public attention to the book, and caused it to make a great stir. So when I proposed that the horsepower should be increased by 33 per cent., and made equivalent to 1,000 watts, I was not at all sorry to find that I had incurred the displeasure of the leader writers in nearly all our scientific papers, and I was quite sure that the attention of those who would not perhaps have thought of it would thereby be drawn to the matter. Some people object to the use of a name, this name “watt.” When you have fresh ideas, you must have fresh words to express those ideas. The watt was a new unit, it must be called by some name, otherwise it could scarcely be conveyed to our minds. The foot, the gallon, the yard, were all new names once; and how do we know that they were not derived from some “John Foot,” “William Gallon,” or “Jack Yard,” or some man whose name was connected with the measure when introduced? The poet says:

“Some mute, inglorious Milton here may rest—
Some Cromwell, guiltless of his country’s blood:”

so in these names some forgotten physicist or mute engineer may be buried. At any rate, we cannot do without names. The ohm, the ampere, the volt, are merely words that express ideas that we all understand; and so does the watt, and so will the 1,000 watts when you come to think over the matter as much as some of us have done.

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At this Conference several other subjects were brought up which attracted a good deal of attention. Professor Rowland brought forward a paper on the theory of dynamos that certainly startled a good many of us; and it led to a discussion that is admirably reported in our scientific papers. I think that the discussion evolved by Professor Rowland's paper on the theory of dynamos deserves the study of every electrician; it brought very strongly into prominence one or two English gentlemen who were present. Professor Fitzgerald, of Dublin, spoke with a considerable amount of power, and showed a mastery of the subject that was pleasant not only to his friends, but must have been gratifying to the Americans who heard him. On this particular subject of dynamos it was truly wonderful how the doctors disagreed. Two could not be found who held the same views on the theory and construction of the dynamo, and that shows that we still have a great deal to learn about the dynamo, and that the true principle of construction of it has yet to be brought out.

It is a very curious thing, and I thought about it at the time, that when you consider the dynamos in use, you see how very little has been done to perfect the direct working dynamo in England. Although the principle of the dynamo originated with Faraday, yet all the early machines, Pacinotti, Gramme. Hefner von Alteneck, Shuckert, Brush, Edison, and several others who have improved the direct action machine, have not been found in England. But when we deal with alternate-current machines, then we find the Wilde, Ferranti, and various others; so that the tendency in England has been very much to improve and work upon the alternate-current machines. In other countries it is exactly the reverse; in fact, in America I never saw one single alternate-current machine. When Professor Forbes wanted an alternate-current machine to illustrate a lecture that he gave, it was with the greatest difficulty that one could be found, and, in fact, it was put together specially for him.

The other subjects brought before this Conference were Earth Currents, Atmospheric Electricity, Accumulators or Secondary Batteries, and Telephones. There was an extremely able paper brought forward by Mr. T.D. Lockwood, the electrician of the American Bell Telephone Company, on Telephones, and the disturbances that influence their working. When that paper is published, it will well be worth your careful examination.

Papers were also read on the Transmission of Energy, and there were papers on many other subjects.

So much for the Electrical Conference.

Now, the Americans at the present moment are suffering from a mania which we, happily, have passed through, that is, the mania of exhibitions.

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While we were at Philadelphia, there was an exceedingly interesting exhibition held. I do not intend to say much about that exhibition, for the simple reason that Professor G. Forbes has promised, during the forthcoming session, to give us a paper describing what he saw there, and his studies at Philadelphia; and I am quite sure that it will be a paper worthy of him, and of you. But, apart from this exhibition at Philadelphia, I could not go anywhere without finding an exhibition. There was one at Chicago, another at St. Louis, another at Boston; everybody was talking about one at Louisville, where I did not go; and there were rumors of great preparations for the "largest exhibition the world has ever seen," according to their own account, at New Orleans. However, I satisfied myself with seeing the exhibition at Philadelphia, which consisted strictly of American goods, and was not of the international nature general to such exhibitions. But it was a fine exhibition, and one that no other single nation could bring together.

Telegraphs.—When I spoke to you in 1878, my remarks were almost entirely confined to telegraphs, for at that day the telephone was not, as a practical instrument, in existence. I brought from America on that occasion the first telephones that were brought to this country. Then the practical application of electricity was applied to telegraphs, and so telegraphs formed the subject of my theme. But while in 1877 I saw a great deal to learn, and picked up a great many wrinkles, and brought back from America a good many processes, I go back there now in 1884, seven years afterward, and I do not find one single advance made—I comeback with scarcely one single wrinkle; and, in fact, while we in England during those seven years have progressed with giant strides, in America, in telegraph matters, they have stood still. But their material progress has been marvelous. In 1877, the mileage of wire belonging to the Western Union Telegraph Company was 200,000 miles; in 1884, they have 433,726 miles of wire; so that during the seven years their mileage of wire has more than doubled. During the same period their number of messages has increased from 28,000,000 to over 40,000,000; their offices from 11,660 to 13,600; and the capital invested in their concern has increased from $40,000,000 to $80,000,000—in fact, there is no more gigantic telegraph organization in this world that this Western Union Telegraph Company. It is a remarkable undertaking, and I do not suppose there is an administration better managed. But for some reason or other that I cannot account for, their scientific progress has not marched with their material progress, and invention has to a certain extent there ceased. There really was only one telegraphic novelty to be found in the States, and that was an instrument by Delany—a multiplex instrument by which six messages could be sent in one or other direction at the same time. It is

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an instrument that is dependent upon the principle introduced by Meyer, where time is divided into a certain number of sections, and where synchronous action is maintained between two instruments. This system has been worked out with great perfection in France by Baudot. We had a paper by Colonel Webber on the subject, before the Society, in which the process was fully described. Delany, in the States, has carried the process a little further, by making it applicable to the ordinary Morse sending. On the Meyer and Baudot principle, the ordinary Morse sender has to wait for certain clicks, which indicate at which moment a letter may be sent; but on the Delany plan each of the six clerks can peg away as he chooses—he can send at any rate he likes, and he is not disturbed in any way by having any sound to guide or control his ear. The Delany is a very promising system. It may not work to long distances; but the apparatus is promised to be brought over to this country, to be exhibited at the Inventors' Exhibition next year, and I can safely say that the Post Office will give every possible facility to try the new invention upon its wires.

One gratifying effect of my visit to the telegraph establishments in America was that, while hitherto we have never hesitated in England to adopt any process or invention that was a distinct advance, whether it came from America or anywhere else, they on the other hand have shown a disinclination to adopt anything British; but they have now adopted our Wheatstone automatic system. That system is at work between New Orleans and Chicago, and New York and New Orleans—1,600 miles. It has given them so much satisfaction that they are going to increase it very largely; so that we really have the proud satisfaction of finding a real, true British invention well established on the other side of the Atlantic.

The next branch that I propose to bring to your notice is the question of the telephone.

The telephone has passed through rather an awkward phase in the States. A very determined attempt has been made to upset the Bell patents in that country; and those who visited the Philadelphia Exhibition saw the instruments there exhibited upon which the advocates of the plaintiff relied. It is said that a very ingenious American, named Drawbaugh, had anticipated all the inventors of every part of the telephone system; that he had invented a receiver before Bell; that he had invented the compressed carbon arrangement before Edison; that he had invented the microphone before our friend Professor Hughes; and that, in fact, he had done everything on the face of the earth to establish the claims set forth. Some of his patents were shown, and I not only had to examine his patents, but I had to go through a great many depositions of the evidence given, and I am bound to confess that a more flimsy case I never saw brought before a court of law. I do not know whether I shall be libelous in expressing my opinion (I will refer to our solicitor before the notes are printed), but I should not hesitate to say that I never saw a more evident conspiracy concocted to try and disturb the position of a well-established patent. However, I have heard that the judgment has been given as the public generally supposed it would be given; because as soon as the case was over the shares of the Bell company, which were at 150, jumped up to 190, and now the decision is given I am told that they will probably reach 290.

We cannot form a conception on this side of the Atlantic of the extent to which telephones are used on the other side of the Atlantic. It is said sometimes that the progress of the telephone on this side of the water has been checked very much by the restrictions brought to bear upon the telephone by the Government of this country. But whatever restrictions have been instituted by our Government upon the adoption of the telephone, they are not to be compared with the restrictions that the poor unfortunate telephone companies have to struggle against on the other side of the Atlantic. There is not a town that does not mulct them in taxes for every pole they erect, and for every wire they extend through the streets. There is not a State that does not exact from them a tax; and I was assured, and I know as a fact, that in one particular case there was one company—a flourishing company—that was mulcted is 75 per cent. of its receipts before it could possibly pay a dividend. Here we only ask the telephone companies to pay to the poor, impoverished British Government 10 per cent.; and 10 per cent. by the side of 75 per cent. certainly cuts but a very sorry figure. But the truth is, the reason why the telephone is flourishing in America is that it is an absolute necessity there for the proper transaction of business. Where you exist in a sort of Turkish bath at from 90 deg. to 100 deg., you want to be saved every possible reason for leaving your office to conduct your business; and the telephone comes in as a means whereby you can do so, and can loll back in your arm chair, with your legs up in the air, with a cigar in your mouth, with a punkah waving over your head, and a bottle of iced water by your side. By the telephone, under such circumstances, business transactions can be carried on with comfort to yourself and to him with whom your business is transacted. We have not similar conditions here. We are always glad of an excuse to get out of our offices. In America, too, servants and messengers are the exception, a boy is not to be had, whereas in England we get an errand boy at half a crown a week. That which costs half a crown here costs 12s. to 15s. in America; and, that being so, it is much better to pay the telephone company a sum that will, at less cost, enable your business to be transacted without the engagement of such a boy.

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The Americans, again, adopt electrical contrivances for all sorts of domestic purposes. There is not a single house in New York, Chicago, or anywhere else that I went into, that has not in the hall a little instrument [producing one] which, by the turn of a pointer and the pressing of a handle, calls for a messenger, a carriage, a cab, express wagon (that is, the fellow who looks after your luggage), a doctor, policeman, fire-alarm, or anything else as may be arranged for. The little instrument communicates to a central office not far off, and in two minutes the doctor, or messenger, or whatever it may be, presents himself.

For fire-alarms and for all sorts of purposes, domestic telegraphy is part and parcel of the nature of an American, and the result was that when the telephone was brought to him, he adopted it with avidity. On this side of the Atlantic domestic telegraphy is at a minimum, and I do not think any one would have a telephone in his house if he could help it.

When you want a thing, you must pay for it. The Americans want the telephone, and they pay for it. In London people grumble very much at having to pay L20 to the Telephone Company for the use of a telephone. I question very much whether L20 a year is quite enough; at any rate, it is not enough if the American charge is taken as a standard. The charge in New York is of two classes—one for a system called the law system, which is applied almost exclusively for the use of lawyers, which is L44 a year; the other being the charge made to the ordinary public, and which will compare with the service rendered in London, which is charged for at L35 a year, against L20 a year in London. The charge in Chicago is L26 a year; in Boston, Philadelphia, and a great many other places it is L25 a year. At Buffalo a mode of charging by results is adopted; everybody pays for each oral message he sends—every time he uses the telephone he pays either four, five, or six cents, according to the number for which he guarantees. Supposing any one of us wanted a telephone at Buffalo, the company will supply it under a guarantee to pay for a minimum of 500 messages per annum. If 1,000 messages are sent, the charge is less *pro rata*, being six cents, if I remember rightly, for each message under 500, and five cents up to 1,000 messages, four cents per message over 1,000 messages; and so everybody pays for what work he does. It is payment by results. The people like the arrangement, the company like it because they make it pay, and the system works well. But I am bound to say that, up to the present moment, Buffalo is the only city in the United States where that method has been adopted.

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The instruments used in the States are no better—in fact, in many cases they are worse—than the instruments we use on this side of the Atlantic. I have heard telephones in this country speak infinitely better than anything that I have heard on the other side of the Atlantic. But they transact their business in America infinitely better than we do; and there is one great reason for this, which is, that in America the public itself falls into the mode of telephone working with the energy of the telegraph operator. They assist the telephone people in every way they can; they take disturbances with a humility that would be simply startling to English subscribers; and they help the workers of the system in every way they can. The result is, that all goes off with great smoothness and comfort. But the switch apparatus used in the American central offices is infinitely superior to anything that I have ever seen over here, excepting at Liverpool.

A new system has just been brought out, called the “multiple” system, which has been very lately introduced. I saw it at many places, especially at Indianapolis, at Boston, and at New York, where three exchanges were worked by it with a rapidity that perfectly startled me. I took the times of a great many transactions, and found that, from the moment a subscriber called to the moment he was put through, only five seconds elapsed; and I am told at Milwaukee, where unfortunately I could not go, but where there is a friend of ours in charge, Mr. Charles Haskins, who is one of our members, and he says he has brought down the rate of working to such a pitch that they are able to arrange that subscribers shall be put through in four seconds.

You will be surprised to learn that there are 986 exchanges at work in the United States. There are 97,423 circuits; there are nearly 90,000 miles of wire used for telephonic purposes; and the number of instruments that have been manufactured amounts to 517,749. Just compare those figures with our little experience on this side of the Atlantic. I have a return showing the number of subscribers in and about New York, comprising the New Jersey division, the Long Island division, Staten Island, Westchester, and New York City, and the total amounts to 10,600 subscribers who are put into communication with each other in the neighborhood of New York alone; and here in England we can only muster 11,000. There are just as many subscribers probably at this moment in New York and its neighborhood as we have in the whole of the United Kingdom.

I am sorry to delay you so long. I have very few more points to bring before you. I spoke only last week so much about the electric light that I have very little to say on that point. High-tension currents are used for electric lighting in America, and all wires are carried overhead along the streets. A more hideous contrivance was probably never invented since the world was created than the system of carrying

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wires overhead through the magnificent streets and cities in America. They spend thousands upon thousands of pounds in beautifying their cities with very fine buildings, and then they disfigure them all by carrying down the pavements the most villainous-looking telegraph posts that ever were constructed. The practice is carried to such an extent, that down Broadway in New York there are no less than six distinct lines of poles; and through the city of New York there are no less than thirty-two separate and distinct companies carrying all their wires through the streets of the city. How the authorities have stood it so long I cannot make out. They object to underground wires—why, one cannot tell. It is something like taking a horse to the pond—you cannot make him drink. So it is with these telephone companies: the public of America and the Town Councils have been trying to force the telephone and telegraph companies to put their wires underground, but they are the horses that are led to the pool, and they will not drink. It is said that the Town Council of Philadelphia have issued most stringent orders that on the first of January next, men with axes and tools are to start out and cut down every pole in the city. It is all very well to threaten; but my impression is that any member of Town Council or any individual of Philadelphia who attempts to do such a thing will be lynched by the first telephone subscriber he meets.

This practice of running overhead wires has great disadvantages when the wires are used for electric-lighting purposes as well as for ordinary telephone or telegraph purposes. No doubt the high-tension system can be carried out overhead with economy; but where overhead wires carrying these heavy currents exist in the neighborhood of telephone circuits, there is every possible liability to accident; and in my short trip I came across seven distinct cases of offices being destroyed by fire, of test boxes being utterly ruined, of a whole house being gutted, and of various accidents, all clearly traceable to contacts arising from the falling of overhead wires, charged with high-tension current, upon telegraph and telephone wires below. The danger is so great and damage so serious that, at Philadelphia, Mr. Plush, the electrician to the Telephone Company, has devised this exceedingly pretty cut-out. It is a little electro-magnetic cut-out that breaks the telephone circuit whenever a current passes into the circuit equal to or more than an ampere. The arrangement works with great ease. It is applied to every telephone circuit simply, to protect the telephone system from electric light wires, that ought never to be allowed anywhere near a telephone circuit.

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Fire-alarms are used in America; but in England, also, the fire systems of Edward Bright, Spagnoletti, and Higgins have been introduced, and in that respect we are in very near the same position as our friends on the other side of the Atlantic. Some members present may remember that, when I described my last visit to America, I mentioned how in Chicago the fire-alarm was worked by an electric method, and I told you a story then that you did not believe, and which I have told over and over again, but nobody has yet believed me, and I began to think that I must have made a mistake somewhere or other. So I meant, when at Chicago this time, to see whether I had been deceived myself. There was very little room for improvement, because, as I told you before, they had very near reached perfection. This is what they did: At the corner of the street where a fire-alarm box is fixed, a handle is pulled down, and the moment that handle is released a current goes to the fire-station; it sounds a gong to call the attention of the men, it unhitches the harness of the horses, the horses run to their allotted positions at the engine, it whips the clothes off every man who is in bed, it opens a trap at the bottom of the bed and the men slide down into their positions on the engine. The whole of that operation takes only six seconds. The perfection to which fire-alarm business has been brought in the States is one of the most interesting applications of electricity there.

Of course during this visit I waited on Mr. Edison. Many of you know that a difference took place between Mr. Edison and myself, and I must confess that I felt a little anxiety as to how I should be received on the other side. It is impossible for any man to receive another with greater kindness and attention than Mr. Edison received me. He took me all over his place and showed me everything, and past differences were not referred to. Mr. Edison is doing an enormous amount of work in steadily plodding away at the electric light business. He has solved the question as far as New York is concerned and as far as central station lighting is concerned; and all we want on this side is to instill more confidence into our capitalists, to try and induce them to unbutton their pockets and give us money to carry out central lighting here.

I met another very distinguished electrician—a man who has hid his light under a bushel—a man whose quiet modesty has kept him very much in the background, but who really has done as much work as any body on that side of the Atlantic, and few have done more on this—and that is Mr. Edward Weston. He is an Englishman who has established himself in New York. He has been working steadily for years at his laboratory, and works and produces plant with all the skill and exactitude that the electrician or mechanic could desire.

Another large factory I went over was that of the Western Electric Company of Chicago, which is the largest manufactory in the States. That company has three large factories. While I was there, the manager, just as a matter of course, handed me over a message which contained an order for 330 arc lamps and for twenty-four dynamo machines. He was very proud of such an order, but he tried to make me believe that it was an every-day occurrence.

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There are no less than 90,000 arc lamps burning in the States every day.

The time has passed very rapidly. I have only just one or two more points to allude to. I think I ought not to conclude without referring to the more immediate things affecting travelers generally and electricians in particular. It is astounding to come across the different experiences narrated by different men who have been on the other side of the Atlantic. One charming companion that we had on board the Parisian has been interviewed, and his remarks appeared in the *Pall Mall Gazette* of Tuesday last, December 9th. There he gave the most pessimist view of life in the United States. He said they were a miserable race—thin, pale faced and haggard, and rushed about as though they were utterly unhappy; and the account our friend gave of what he saw in the United States evidently shows that the heat that did not affect some of us so very much must have produced upon Mr. Capper a most severe bilious attack. Well, his experiences are not mine. Throughout the whole States I received kindnesses and attentions that I can never forget. I had the pleasure of staying in the houses of most charming people. I found that whenever you met an educated American gentleman there was no distinction to be drawn between him and an English gentleman. His ways of living, his modes of thought, his amusements, his entertainments, are the same as ours; there is no difference whatever to be found. In Mr. Capper's case I can readily imagine that he spent most of his time in the halls of hotels, and there you do see those wild fellows rushing about; they convert the hall of the hotel into a mere stock exchange, and look just as uncomfortable as our "stags" who run about Capel Court. You may just as well enter a betting-ring and come away with the impression that the members represent English society, or that that is the most refined manner in which English gentlemen enjoy themselves.

Well, gentlemen, there are just as exceptional peculiarities here as on the other side of the water. The Americans are the most charming people on this earth. When we enter their houses and come to know them, they treat us in a way that cannot be forgotten. I noticed a very great change since I was in America before. Whether it is a greater acquaintance with them or not I cannot say, but there is an absence of that which we can only express by a certain word called "cockiness." It struck me at one time that there was a good deal of cockiness on that side of the Atlantic, that has entirely disappeared. Constant intercourse between the two countries is gradually bringing out a regular unanimity of feeling and the same mode of thought.

But there are some things in which the Americans are a little lax, especially in their history. At one of their exhibitions that I visited, for instance, there was a placard put up—

"The steed called Lightning, say the Fates,
Was tamed in the United States.
'Twas Franklin's hand that caught the horse;
'Twas harnessed by Professor Morse."

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Now, considering that Franklin made his discovery in 1752, and the United States were not formed till about thirty years afterward, it is rather "transmogrifying" history to say the lightning was tamed in the United States.

Again, where the notice about Professor Morse was put, they say that the instrument was invented by Morse in 1846, while alongside it is shown the very slip which sent the message, dated 1844; so that the slip of the original message sent by Morse was sent by his instrument two years before it was invented.

Again, that favorite old instrument of ours which we are so proud of, the hatchment telegraph of Cooke and Wheatstone, invented in 1837, was labeled "Whetstone and Cook, 1840," so while I am sorry to say they are loose in their history, they are tight in their friendships, and all the visitors receive the warmest possible welcome from them generally, and especially so from every member of our Society belonging to the States.

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THE HOUSE OF A THOUSAND TERRORS, ROTTERDAM.

[Illustration: THE HOUSE OF A THOUSAND TERRORS, ROTTERDAM.]

This building, which is situated at the corner of the Groote Market and the Hang, is one of the oldest houses in Rotterdam, besides being one of the most interesting from a historical point of view. There is a tradition which states that when the city was invaded and pillaged by the Spaniards, who in accordance with their usual custom, proceeded to put the inhabitants to the sword, without regard to age or sex, a large number of the leading citizens took refuge within the building, and having secured and barricaded the entrance, they killed a kid and allowed the blood to flow beneath the door into the street; seeing which the soldiery concluded that those inside had already been massacred, and without troubling to force an entry passed on, leaving them unmolested. Here the unhappy citizens remained for three days without food, by which time the danger had passed away, and they were enabled to effect their escape. It is from this incident that the building takes its name. The house is built in a species of irregular bond with bricks of varying lengths, the strings, labels, copings, *etc*., being in stone. The upper portion remains in pretty much the same condition as it existed in the 16th century, but is much disfigured by modern paint, which has been laid over the whole of the exterior with no sparing hand. Within the last few years the present shop windows facing the Groote Market have been put up and various slight alterations made to the lower part of the building to suit the requirements of the present occupiers. The drawing has been prepared from detail sketches made on the spot.—*W.E. Pinkerton, in Building News*.

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ON THE ORIGIN AND STRUCTURE OF COAL.

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The origin of coal, that combustible which is distributed over the earth in all latitudes, from the frozen regions of Greenland to Zambesi in the tropics, utilized by the Chinese from the remotest antiquity for the baking of pottery and porcelain, employed by the Greeks for working iron, and now the indispensable element of the largest as well of the smallest industries, is far from being sufficiently clear. The most varied hypotheses have been offered to explain its formation. To cite them all would not be an easy thing to do, and so we shall recall but three: (1) It has been considered as the result of eruptions of bitumen coming from the depths, and covering and penetrating masses of leaves, branches, bark, wood, roots, *etc*., of trees that had accumulated in shallow water, and whose most delicate relief and finest impressions have been preserved by this species of tar solidified by cooling. (2) It has also been considered as the result of the more or less complete decomposition of plants under the influence of heat and dampness, which has led them to pass successively through the following principal stages: *peat*, *lignite*, *bituminous coal*, *anthracite*. (3) Finally, while admitting that the decomposition of plants can cause organic matter to assume these different states, other scientists think that it is not necessary for such matter to have been peat and lignite in order to become coal, and that at the carboniferous epoch plants were capable of passing directly to the state of coal if the conditions were favorable; and, in the same way, in the secondary and tertiary epochs the alteration of vegetable tissues generally led to lignite, while now they give rise to peat. In other words, the nature of the combustible formed at every great epoch depended upon general climatic conditions and local chemical action. Anthracite and bituminous coal would have belonged especially to primary times, lignites to secondary and tertiary times, and peat to our own epoch, without the peat ever being able to become lignites or the latter coal.

As for the accumulation of large masses of the combustible in certain regions and its entire absence in others belonging to the same formation, that is attributed, now to the presence of immense forests growing upon a low, damp soil, exposed to alternate rising and sinking, and whose debris kept on accumulating during the periods of upheaval, under the influence of a powerful vegetation, and now to the transportation of plants of all sorts, that had been uprooted in the riparian forests by torrents and rivers, to lakes of wide extent or to estuaries. Not being able to enter in this place into the details of the various hypotheses, or to thoroughly discuss them, we shall be content to make known a few facts that have been recently observed, and that will throw a little light upon certain still obscure points regarding the formation of coal.

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(1) According to the first theory, if the impressions which we often find in coal (such as the leaves of Cordaites, bark of Sigillarias and Lepidodendrons, wood of Cordaites, Calamodendrons, *etc*.) are but simple and superficial mouldings, executed by a peculiar bitumen, formerly fluid, now solidified, and resembling in its properties no other bitumen known, we ought not to find in the interior any trace of preservation or any evidence of structure. Now, upon making preparations that are sufficiently thin to be transparent, from coal apparently formed of impressions of the leaves of Cordaites, we succeed in distinguishing (in a section perpendicular to the limb) the cuticle and the first row of epidermic cells, the vascular bundles that correspond to the veins and the bands of hypodermic libers; but the loose, thin-walled cells of the mesophyllum are not seen, because they have been crushed by pressure, and their walls touch each other. The portions of coal that contain impressions of the bark of Sigillaria and Lepidodendron allow the elongated, suberose tissue characteristic of such bark to be still more clearly seen.

Were we to admit that the bitumen was sufficiently fluid to penetrate all parts of the vegetable debris, as silica and carbonates of lime and iron have done in so many cases, we should meet with one great difficulty. In fact, the number of fragments of coal *isolated* in schists and sandstone is very large, and *without any communication* with veins of coal or of bitumen that could have penetrated the vegetable. We cannot, then, for an instant admit such a hypothesis. Neither can we admit that the penetration of the plants by bitumen was effected at a certain distance, and that they have been transported, after the operation, to the places where we now find them, since it is not rare to find at Commentry trunks of Calamodendrons, Anthropitus, and ferns which are still provided with roots from 15 to 30 feet in length, and the carbonized wood of which surrounds a pith that has been replaced by a stony mould. The fragile ligneous cylinder would certainly have been broken during such transportation.

The carbonized specimens were never fluid or pasty, since there are some that have left their impressions with the finest details in the schists and sandstones, but none of the latter that has left its traces upon the coal. The surface of the isolated specimens is well defined, and their separation from the gangue (which has never been penetrated) is of the easiest character.

The facts just pointed out are entirely contrary to the theory of the formation of coal by way of eruption of bitumen.

(2) The place occupied by peats, lignites, and bituminous and anthracite coal in sedimentary grounds, and the organic structure that we find less and less distinct in measure as we pass from one of these combustibles to one more ancient, have given rise to the theory mentioned above, *viz*., that vegetable matter having, under the prolonged action of heat and moisture, experienced a greater and greater alteration, passed successively through the different states whose composition is indicated in the following table:

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	H.	C.	O.	N.	Coke.	Ashes.	Density.
Peat	5.63	57.03	29.67	2.09	——	5.58	——
Lignite	5.59	70.49	17.2	1.73	49.1	4.99	1.2
Bitumin. coal	5.14	87.45	4	1.63	68	1.78	1.29
Anthracite	3.3	92.5	2.53	——	89.5	1.58	1.3

Aside from the fact that anthracite is not met with solely in the lower coal measures, but is found in the middle and upper ones, and that bituminous coal itself is met with quite abundantly in the secondary formations, and even in tertiary ones, it seems to result from recent observations that if vegetable matter, when once converted into lignites, coal, *etc*., be preserved against the action of air and mineral waters by sufficient thick and impermeable strata of earth, preserves the chemical composition that it possessed before burial. The coal measures of Commentry, as well as certain others, such as those of Bezenet, Swansea, *etc*., contain quite a large quantity of coal gravel in sandstone or argillaceous rocks. These fragments sometimes exhibit a fracture analogous to that of ordinary coal, with sharp angles that show that they have not been rolled; and the sandstone has taken their exact details, which are found in hollow form in the gangue. In other cases these fragments exhibit the aspect of genuine shingle or rolled pebbles. These pebbles of coal have not been misshapen under the pressure of the surrounding sandstone, nor have they shrunk since their burial and the solidification of the gangue, for their surface is in contact with the internal surface of their matrix. Everything leads to the belief that they were extracted from pre-existing coal deposits that already possessed a definite hardness and bulk, at the same time as were the gravels and sand in which they are imprisoned. It became of interest, then, to ascertain the age to which the formation of these fragments might be referred, they being evidently more ancient than those considered above, which, as we have seen, could not have been transported in this state on account of their dimensions and the fragility of made coal. Thanks to the kindness of Mr. Fayol, we have been enabled to make such researches upon numerous specimens that were still inclosed in their sandstone gangue and that had been collected in the coal strata of Commentry. In some of their physical properties they differ from the more recent isolated fragments and from the ordinary coal of this deposit. They are less compact, their density is less, and a thin film of water deposited upon their surface is promptly absorbed, thus indicating a certain amount of porosity. Their fracture is dull and they are striped with shining coal, and can be more easily sliced with a razor.

From a fresh fracture, we find by the lens, or microscope, that some of them are formed of ordinary coal, that is, composed of plates of variable thickness, brilliant and dull, with or without traces of organization, and others of divers bits of wood whose structure is preserved. When reduced to thin, transparent plates, these latter show us the organization of the wood of *Arthropitus*, *Cordaites*, and *Calamodendron*, and of the petioles of *Aulacopteris*, that is to say, of the ligneous and arborescent plants that we most usually meet with in the coal measures of Commentry in the state of impression or of coal.

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In a certain number of specimens the diminution in volume of the tracheae is less than that that we have observed in the same organs of corresponding genera. The quantity of oxygen and hydrogen that they contain is greater, and seems to bring them near the lignites.

We cannot attribute these differences to the nature of the plants converted into coal, since we have just seen that they are the same in the one case as in the other. Neither does time count for anything here, since, according to accepted ideas, the burial having been longer, the carbonization ought to have been more perfect, while the contrary is the case.

If we admit (1) that vegetable remains alter more and more through maceration in ordinary water and in certain mineral waters; (2) that, beginning with their burial in sufficiently thick strata of clay and sand, their chemical composition scarcely varies any further; and (3) that these are important changes only as regards their physical properties, due to loss of water and compression, we succeed quite easily in learning what has occurred.

In fact, when, as a consequence of the aforesaid alteration, the vegetable matter had taken the chemical composition that we find in the less advanced coal of the pebbles, it was in the first place covered with sand and protected against further destruction, and it gradually acquired the physical properties that we now find in it.
At the period that channels were formed, the coal was torn from the beds in fragments, and these latter were rolled about for a time, sometimes being broken, and then covered anew, and this too at the same time as were the plants less advanced in composition that we meet with at the same level. These latter, being like them protected against ulterior alteration, we now find less advanced in carbonization (notwithstanding their more ancient origin) than the other vegetable fragments that were converted into coal after them, but that were more thoroughly altered at the time of

burial.

There are yet a few other important deductions to be made from the foregoing facts: (1) the same coal basin may, at the same level, contain fragments of coal of very different ages; (2) its contour may have been much modified owing to the ravines made by the water which transported the ancient parts into the lowest regions of the basin; and (3) finally, since the most recent sandstones and schists of the same basin may contain coal which is more ancient, but which is formed from the same species of plants that we find at this more recent level, we must admit that the conversion of the vegetable tissues into coal was relatively rapid, and far from requiring an enormous length of time, as we are generally led to believe.

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If, then, lignites have not become soft coal, and if the latter has not become anthracite, it is not that time was wanting, but climatic conditions and environment. Most analyses of specimens of coal have been made up to the present with fragments so selected as to give a mean composition of the mass; it is rare that trouble has been taken to select bits of wood, bark, *etc*., of the same plant, determined in advance by means of thin and transparent sections in order to assure the chemist of the sole origin and of the absolute purity of the coal submitted to analysis. This void has been partially fitted, and we give in the following table the results published by Mr. Carnot of analyses made of different portions of plants previously determined by us:

	Carbon	Hydrogen	Oxygen	Nitrogen
1. Calamodendron (5 specimens)	82.95	4.78	11.89	0.48
2. Cordaites (4 specimens)	82.94	4.88	11.84	0.44
3. Lepidodendron (3 specimens)	83.28	4.88	11.45	0.39
4. Psaronius (4 specimens)	81.64	4.80	13.11	0.44
			\——v——/	
5. Ptychopteris (1 specimen)	80.62	4.85	14.53	
6. Megaphyton (1 specimen)	83.37	4.40	12.23	

As seen from this table, the elementary composition of the various specimens is nearly the same, notwithstanding that the selection was made from among plants that are widely separated in the botanical scale, or from among very different parts of plants. In fact, with Numbers 1 and 2 the analysis was made solely of the wood, and with No. 3 only of the prosenchymatous and suberose parts of the bark. Here we remark a slight increase in carbon, as should be the case. With No. 4 the analysis was of the roots and the parenchymatous tissue that descends along the stem, and with No. 6 of the bark and small roots. One will remark here again a slight increase in the proportion of carbon, as was to be foreseen. The elementary composition found nearly corresponds with that of the coal taken from the large Commentry deposit.

	Carbon.	Hydrogen.	Oxygen and Nitrogen.
Regnault	82.92	5.39	11.78
Mr Carnot	83.21	5.57	11.22

Although the chemical composition is nearly the same, the manner in which the different species or fragments of vegetables behave under distillation is quite different.

In fact, according to Mr. Carnot, the plants already cited furnish the following results on distillation:

	Volatile matters.	Fixed residue.	Coke.
Calamodendron	35.5	64.7	Well agglomerated.
Cordaites	42.1	57.8	Quite porous.
Lepidodendron	34.7	55.3	Well agglomerated.
Psaronius	29.4	60.5	Slightly porous.
Ptychopteris	39.4	60.5	
Megaphyton	35.5	64.5	Well agglomerated.
Coal of the Great Bed	40.5	59.5	Slightly porous.

These differences in the proportions of volatile substances, of fixed residua, and of density in the coke obtained seem to be in harmony with the primitive organic nature of the carbonized tissues. We know, in fact, that the wood of the Calamodendrons is composed of alternately radiating bands formed of ligneous and thick walled prosenchymatous tissue, while the wood of Cordaites, which is less dense, recalls that of certain coniferae of the present day (Araucariae).

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We have remarked above that the portions of Lepidodendron analyzed belonged to that part of the bark that was considerably thickened and lignefied. So too the portion of the Megaphyton that was submitted to distillation was the external part of the hard bark, formed of hypodermic fibers and traversed by small roots. The Psaronius, on the contrary, was represented by a mixture of roots and of parenchymatous tissue in which they descend along the trunk.

It results from these remarks that we may admit that those parts of the vegetable that are ordinarily hard, compact, and profoundly lignefied furnish a compact coke and relatively less volatile matter, while the tissues that are usually not much lignefied, or are parenchymatous, give a bubbly, porous coke and a larger quantity of gas. The influence of the varied mode of grouping of the elements in the primitive tissues is again found, then, even after carbonization, and is shown by the notable differences in the quantities and physical properties of the products of distillation.

The elementary chemical composition, which is perceptibly the same in the specimens isolated in the sandstones and in those taken from the great deposit, demonstrates that the difference in composition of the environment serving as gangue did not have a great influence upon the definitive state of the coal, a conclusion that we had already reached upon examining the structure and properties of the coal pebbles.

We may get an idea of the nearly similar composition of the coal produced by very different plants or parts thereof, in remarking that as the cells, fibers, and vessels are formed of cellulose, and some of them isomeric, the difference in composition is especially connected with the contents of the cells, canals, *etc*., such as protoplasm, oils, resins, gums, sugars, and various acids, various incrustations, *etc*. After the prolonged action of water that was more or less mineralized and of multiple organisms, matters that were soluble, or that were rendered so by maceration, were removed, and the organic skeletons of the different plants were brought to a nearly similar centesimal composition representing the carbonized derivatives of the cellulose and its isomers. The vegetable debris thus transformed, but still resistant and elastic, were the ones that were petrified in the mineral waters or covered with sand and clay. Under the influence of gradual pressure, and of a desiccation brought about by it, and by a rising of the ground, the walls of the organic elements came into contact, and the physical properties that we now see gradually made their appearance.

The waters derived from a prolonged steeping of vegetables, and charged with all the soluble principles extracted therefrom, have, after their sojourn in a proper medium, deposited the carbonized residua that have themselves become soluble, and have there formed masses of combustibles of a different composition from that resulting from the skeletons of plants, such as *cannel coal, pitch coal, boghead, etc.*

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A thin section of a piece of Commentry cannel coal shows that this substance consists of a yellowish-brown amorphous mass holding here and there in suspension very different plant organs, such as fragments of Cordaites, leaves, ferns, microspores, macrospores, pollen grains, rootlets, *etc*., exactly as would have done a gelatinous mass that upon coagulating in a liquid had carried along with it all the solid bodies that had accidentally fallen into it and that were in suspension.

It is evident (as we have demonstrated) that other cannel coals may show different plant organs, or even contain none at all, their presence appearing to be accidental. The composition itself of cannel coal must be, in our theory, connected with the chemical nature of the materials from whence it is derived, and that were first dissolved and then became insoluble through carbonization. Several preparations made from Australian (New South Wales), Autun, *etc*., boghead have shown us merely a yellowish-brown amorphous mass holding in suspension lens-shaped or radiating floccose masses which it is scarcely possible to refer to any known vegetable organism.

Among the theories that we have cited in the beginning, the one that best agrees with the facts that we have pointed out is the third, which would admit, then, two things in the formation of coal. The first would include the different chemical reactions which cannot yet be determined, but which would have brought the vegetable matter now to the state of soft coal (with its different varieties), and now to the state of anthracite. The second would comprehend the preservation, through burial, of the organic matter in the stage of carbonization that it had reached, and as the result of compression and gradual desiccation, the development of the physical properties that we now find in the different carbonized substances.

We annex to this article a number of figures made from preparations of various coals. These preparations were obtained by making the fragments sufficiently thin without the aid of any chemical reagent, so as to avoid the reproach that things were made to appear that the coal did not contain. This slow and delicate method is not capable of revealing all the organisms That the carbonaceous substance contains, but, per contra, one is riot absolutely sure of the pre-existence of everything that resembles organs or fragments of such that he distinguishes therein by means of the microscope.

Our researches, as we have above stated, have been confined to different cannel coals, anthracite, boghead, and coal plants isolated either in coal pebbles, or in schists and sandstones.

[Illustration: 12a: FIG. 1.—Lancashire cannel coal; longitudinal section, X200.]

[Illustration: 12b: FIG. 2.—Lancashire cannel coal; transverse section, X200.]

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Figs. 1 and 2 (magnified two hundred times) represent two sections, made in rectangular planes, of fragments of Lancashire cannel coal. In a certain measure, they remind one of Figs. 4 and 5, Pl 11, of Witham's "Internal Structure of Fossil Vegetables," and which were drawn from specimens of cannel coal derived likewise from Lancashire, but which are not so highly magnified. There is an interesting fact to note in this coincidence, and that is that this structure, which is so difficult to explain in its details, is not accidental, but a consequence of the nature of the materials that served to produce the coal of this region. In the midst of a mass of blackish debris, *a*, organic and inorganic, and immersed in an amorphous and transparent gangue, we find a few recognizable fragments, such as thick-walled macrospores, *b*, of various sizes, bits of flattened petioles, *c*, pollen grains, *d*, debris of bark, *etc*. In Fig. 2 all these different remains are cut either obliquely or longitudinally, and are not very recognizable. It is not rare to meet with a sort of vacuity, *e*, filled with clearer matter of resinoid aspect, without organization.

[Illustration: 12c: FIG. 3.—Commentry cannel coal, X200.]

In Fig. 3, which represents a section made from Commentry cannel coal, the number of recognizable organs in the midst of the mass of debris is much larger. Thus, at *a* we see a macrospore, at *b* a fragment of the coat of a macrospore, at *c* another macrospore having a silicified nucleus, such as has been found in no other case, at *d* we have a transverse section of a vascular bundle, at *e* a longitudinal section of a rootlet traversed by another one, at *f* we have a transverse section of another rootlet, at *g* an almost entire portion of the vascular bundle of a root, and at *h* we see large pollen grains recalling those that we meet with in the silicified seeds from Saint Etienne.

Cannel coal, then, shows that it is formed of a sort of dark brown gangue of resinoid aspect (when a thin section of it is examined) holding in suspension indeterminable black organic and inorganic debris, which are arranged in layers, and in the midst of which (according to the locality and the fragment studied) is found a varying number of easily recognized vegetable organs.

[Illustration: 12d: FIG. 4.—Pennsylvania anthracite, X200.]

It is very rare that anthracite offers any discernible trace of organization. Preparations made from fragments of Sable and Lamore coal could not be made sufficiently thin to be transparent; the mass remained very opaque, and the clearest parts exhibited merely amorphous, irregular granulations. Still, fragments of anthracite from Pennsylvania furnished, amid a dominant mass of dark, yellow-brown, structureless substance, a few organized vegetable debris, such as a fragment of a vascular bundle with radiating elements (Fig. 4, *a*), a macrospore, *b*, and a few pollen grains or microspores, *c*.

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[Illustration: 12e: FIG. 5.—Boghead
from New South Wales, X500.]

From what precedes it seems to result, then, that anthracite is in a much less appreciable state of preservation than cannel coal, and that it is only rarely, and according to locality, that we can discover vegetable organs in it. Soft coal comes nearer to amorphous carbon. Boghead appears to be of an entirely different character (Fig. 5, magnified X300). It is easily reduced to a thin transparent plate, and shows itself to be formed of a multitude of very small lenses, differing in size and shape, and much more transparent than the bands that separate them. In the interior of these lenses we distinguish very fine lines radiating from the center and afterward branching several times. The ramifications are lost in the periphery amid fine granulations that resemble spores. We might say that we here had to do with numerous mycelia moulded in a slightly colored resin. Preparations made from New South Wales and Autun boghead presented the same aspect.

If boghead was derived from the carbonization of parts that were soluble, or that became so through maceration, and were made insoluble at a given moment by carbonization, we can understand the very peculiar aspect that this combustible presents when it is seen under the microscope.

The following figures were made in order to show the details of anatomical structure that are still visible in coal, and to permit of estimating the shrinkage that the organic substance has undergone in becoming converted into coal.

It is not rare in coal mines to find fragments of wood, of which a portion has been preserved by carbonates of iron and lime, and another portion converted into coal. This being the case, it was considered of interest to ascertain whether the carbonized portion had preserved a structure that was still recognizable, and, in such an event, to compare this structure with that of the portion of the specimen that was preserved in all its details by mineralization.

[Illustration: 12f: FIG. 6.—*Arthropitus gallica*, St. Etienne; transverse section, X200.]

Fig. 6 shows a transverse section of a specimen of *Arthropitus Gallica* found under such conditions. The region marked c is carbonized; the organic elements of the wood-cells, tracheae, *etc*., have undergone but little change in shape. Moreover, no change at all exists in the internal parts of another specimen (Fig. 8), where we easily distinguish by their form and dimensions the ligneous cells, *aa*, and the elements, *bb*, of the wood itself.

[Illustration: 12h: FIG. 8.—*Arthropitus gallica*, St. Etienne; transverse section through the carbonized part.]

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In the region, *b*, of Fig. 6, the ligneous elements have undergone an evident change of form, and the walls have been broken. This region, already filled by petrifying salts, but not completely hardened, has not been able to resist, as the region, *a*, an external pressure, and has become more or less misshapened. As for the not yet mineralized external portion, *c*, it has completely given way under the pressure, the walls of the different organic elements have come into contact, the calcareous or other salts have been expressed, and this region exhibits the aspect of ordinary coal, while at the same time preserving a little more hardness on account of the small quantity of mineral salts that has remained in them despite the compression.

From the standpoint of carbonization there seems to us but little difference between the organic elements that occupy the region, *a*, and those that occupy *b*. If the former had not been filled with hardened petrifying matter, they would have been compressed and flattened like those of region *c*, and would have given a compact and brilliant coal, having very likely before petrifaction reached the same degree of carbonization as the latter. The layer of coal in contact with the carbonized or silicified part of the specimens is due, then, to a compression of the organic elements already chemically carbonized, but in which the mineral matter was not yet hardened and was able to escape.

[Illustration: 12g: FIG. 7.—*Arthropitus gallica*, St. Etienne; tangential longitudinal section.]

If this be so, we ought to find the remains of organic structure in this region *c*. In fact, on referring to Fig. 7, which represents a tangential, longitudinal section of the same specimen, we perceive at *ab* a ligneous duct and some unchanged tracheae situated in the carbonized region, and then at *c* the same elements, though flattened, in which, however, we still clearly distinguish the bands of the tracheae; at *d* is found a trachea whose contents were already solidified, and which has not been flattened; then, near the surface, in the region, *e*, the pressure having been greater, it is no longer possible to recognize traces of organization in a tangential section. In a large number of cases, the fact that the coal does not seem to be organized must be due to the too great compression that the carbonized cells and vessels have undergone when yet soft and elastic, at the time this slow but continuous pressure was being exerted.

It also became of interest to find out whether, through the very fact of carbonization, the dimensions of the organic elements had perceptibly varied—a sort of research that presents certain difficulties. At present we have no living plant that is comparable, even remotely, with those that grew during the coal epoch. Moreover, the organic elements have absolutely nothing constant in their dimensions.

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Still, if we limit ourselves to a comparison of the same carbonized wood, preserved on the one hand by petrifaction, and on the other hand non-mineralized, we find a very perceptible diminution in bulk. The elements have contracted in length, breadth, and thickness, but principally in the direction of the compression that they have undergone in the purely carbonized specimens.

In the vicinity of the carbonized portions, those of the tracheae that have not done so have perceptibly preserved their primitive length, which has, so to speak, been maintained by their neighbors, but their other dimensions have become much smaller—a quarter in thickness and half in length.

[Illustration: 12i: FIG. 9.—*Calamodendron,* Commentry; prosenchymatous portion of the wood carbonized, X200.]

If the two fragments of the same wood are, one of them silicified and the other simply carbonized and preserved in sandstone, the diminution in volume will have occurred in all directions in the latter of the two.

[Illustration: 12j: FIG. 10.—*Calamodendron,* fragment of the vascular portion of the wood carbonized.]

Figs. 9 and 11, which represent a portion of the *fibrous* region of Calamodendron wood, may give an idea of the shrinkage that has taken place therein. In Figs. 11 and 12, which show a few tracheae and medullary rays of the ligneous bands of the same plant, we observe the same phenomenon. We might cite a large number of analogous examples, but shall be content to give the following: Figs. 13 and 15 represent radial and tangential sections of the bark of *Syringodendron pes-caprae*. This is the first time that one has had before his eyes the anatomical structure of the bark of a *Syringodendron*, a plant which

has not yet been found in a petrified state.
It is coal, then, with its structure preserved, that allows of a verification of the theory advanced by several scientists that the often bulky trunks of *Syringodendron* are bases of *Sigillariae*.

[Illustration: 12k: FIG. 11.—*Calamodendron*, from Autun; prosenchymatous portion of the wood silicified, X200.]

[Illustration: 12l: FIG. 12.—*Calamodendron*, from Autun; vascular portion of the wood silicified.]

If we refer to Fig. 13, which represents a radial vertical section running through the center of one of the scars that permitted the specimen to be determined, we shall observe, in fact, a tissue formed of rectangular cells, longer than wide, arranged in horizontal series, and very analogous in their aspect to those that we have described in the suberose region of the bark of Sigillariae. Fig. 15 shows in tangential section the fibrous aspect of this tissue, which has been rendered denser through compression. Fig. 14 shows it restored. In Fig. 13, the external part of the bark is occupied by a thick layer of cellular tissue that exists over the entire surface of the

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trunk, but particularly thick near the scars, exactly as in the barks of the Sigillariae that we have formerly described. Finally, at *b*, we recognize the undoubted traces of a vascular bundle running to the leaves. If the bundle appears to be larger than that of the Sigillariae, this is due to the flattening that the trunk has undergone, the effect of this having been to spread the bundle out in a vertical plane, although its greatest width in the first place was in a horizontal one.

[Illustration: 12m: FIG. 13.—*Syringodendron pes-caprae*; from Saarbruck; radial vertical section, X200.]

[Illustration: 12n: FIG. 14.—Suberose cells restored.]

In anatomical structure, the barks of the Syringodendrons are, then, analogous to those of the Sigillariae. If, now, we compare the dimensions of the tissues of these barks with the same silicified tissues of the barks of Sigillariae, we shall find that there was likewise a diminution in the dimensions, but yet a less pronounced one than in the woods that we have previously spoken of. The corky nature of this region of the bark was likely richer in carbonizable elements than the wood properly so called, and had, in consequence, to undergo much less shrinkage.—*Dr. B. Renault (of Paris Museum) in Le Genie Civil*.

[Illustration: 12o: FIG. 15.—*Syringodendron pes-caprae;* tangential vertical section in the corky part of the bark, X200.]

DESCRIPTION OF THE FIGURES.—Fig. 1, Lancashire cannel coal; longitudinal section, X200. Fig. 2, Lancashire cannel coal; transverse section, X200. Fig. 3. Commentry cannel coal, X200. Fig. 4, Pennsylvania anthracite, X200. Fig. 5, Boghead from New South Wales, X500. Fig. 6, *Arthropitus* *gallica*, St. Etienne; transverse section, X200. Fig. 7, same; tangential longitudinal section. Fig. 8, same; transverse section through the carbonized part. Fig. 9. *Calamodendron*, Commentry; prosenchymatous portion of the wood carbonized, X200. Fig. 10, same; fragment of the vascular portion of the wood carbonized. Fig. 11, same, from Autun; prosenchymatous portion of the wood silicified, X200. Fig. 12, same, Autun; vascular portion of the wood silicified. Fig. 13, *Syringodendron pes-caprae*; from Saarbruck; radial vertical section, X200. Fig. 14, Suberose cells restored. Fig. 15. *Syringodendron pes-caprae*; tangential vertical section in the corky part of the bark, X200.

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ICE BOAT RACES ON THE MUEGGELSEE, NEAR BERLIN.

The interest in sports of different kinds is increasing considerably in the capital of the German Empire. Oarsmen and sailors show their ability in grand regattas; roller-skating rinks are very, popular; numerous bicycle clubs arrange grand tournaments; and training, starting, trotting, swimming, turning, fencing, walking, and running are practiced everywhere. As this winter has been quite severe in Germany, first class courses have been made for ice boats. Ice boat, races are well known in the United States, but are quite novel in Germany; at least, in the neighborhood of Berlin, as they have been known only on the coast of the Baltic Sea.

[Illustration: ICE BOAT RACES ON THE MUEGGELSEE, NEAR BERLIN.]

These vessels are quite simple in construction, the base consisting of an equilateral triangle made of beams and provided at the corners with runners. The two front runners are fixed, but the one at the apex of the triangle is pivoted, and serves as a rudder. The mast is on the front cross beam, and between the front cross beam and the side beams sufficient space is left for the helmsman.

The annexed cut, taken from the *Illustrirte Zeitung*, shows a race of the above described ice boats on the Mueggelsee (Mueggel Lake), near Berlin. It will be seen from the clumsy construction of the boats that the Germans have not yet learned the art of building these vehicles.

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LABOR AND WAGES IN AMERICA.

[Footnote: A paper recently read before the Society of Arts, London.]

By D. PIDGEON.

The United States of America are, collectively, of such vast extent, and, singly, so individualized in character, that to speak of their labor conditions as a whole would be as impossible, in an hour's address, as to describe their physical geography or geology in a similar space of time. I shall, therefore, confine what I have to say this evening on the subject of labor and wages in America to a consideration of the industrial condition of certain

Eastern States, which, being essentially manufacturing districts, offer the best instances for comparison with the labor conditions of our own country. That this field is of adequate extent and of typical character may be inferred from the fact that the three States composing it, *viz*.. New York, Massachusetts, and Connecticut, contain together nearly one-half of the whole manufacturing population of America, while Connecticut and Massachusetts are the very cradle of American manufacture, and the home of the typical Yankee artisan. In addition, the State of Massachusetts is distinguished by possessing a Bureau of Statistics of Labor, whose sole business is to ventilate industrial questions, and to collect such facts as will afford the statesman a sound basis for industrial legislation. We shall find ourselves, in the sequel, indebted for spine of our chief conclusions to this excellent public institution.

If we ask ourselves, at the outset of the inquiry, "Who and what are the operatives of manufacturing America?" the answer involves a distinction which cannot be too strongly insisted upon, or too carefully kept in mind. These people consist, first, of native-born, and, secondly, of alien workers. The United States census, reckoning every child born in the country as an American, even if both his parents be foreigners, I would make it appear that only six and a half millions out of its fifty millions are of alien birth, but, for our purpose, these figures are misleading. There is a vast difference, in

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many important respects, between “Americans” derived from a stock long settled in the States and “Americans” with two or even with one alien parent. In the former case, the hereditary sense of social equality, the teaching of the common school, and the influence of democratic institutions, produce a certain type of character which I distinguish by the epithet “American” because it is of truly national origin. In the latter case, the so-called “American” may really be a German, an Irishman, an Englishman, or a Swede, but the qualities which I would distinguish by the word “American” have not yet been developed in him, although they will probably be exhibited by his later descendants.

Setting the census figures aside, therefore, we find, from the Registration Reports of Massachusetts, that fifty-four out of every hundred persons who die within the limits of this State are of foreign parentage. Now bearing in mind that Massachusetts is essentially a Yankee State, where comparatively few European emigrants settle, it seems probable that, going back several generations, the numbers, even of Massachusetts men, who may be truly called “Americans” would dwindle considerably. These men, however, the children of equality, of the common school, and of democratic institutions, may be considered as leaven, leavening the lump of European emigration, and shaping, so far as they can, the character of the American; people that is yet to be.

Native American labor is best described by reference to a recent past, when it filled all the factories of the United States, and challenged, by its high tone, the admiration of Europe. At the beginning of this century, public opinion in America was most unfriendly to the establishment of manufactories, so great were the complaints of these made in Europe as seats of vice and disease. Thus, when Humphreysville, the first industrial village in America, was built, in 1804, by the Hon. David Humphreys, who wished to see the colony independent of the mother country for her supplies of manufactured goods, parents refused to place their children in his factories until legislation had first made the mill-owner responsible both for the education and morality of his operatives. Similarly, when the cotton mills of Lowell, and the silk mills of Hartford, began to rise, between 1832 and 1840, the American people held the capitalist responsible for the moral, mental, and physical health of the people whom he employed, with the result that all England wondered at the stories of factory operatives, and their so-called “refinements,” which were given to this country by writers like Harriett Martineau and Charles Dickens.

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Lowell, between the years 1832 and 1850, was, perhaps, the most remarkable manufacturing town in the world. Help, in the new cotton mills, was in great demand, and what were then thought very high wages were freely offered, so that, in spite of the national prejudice against factory labor, operatives began to flow from many quarters into the mills. These people were, for the most part, the daughters of farmers, storekeepers, and mechanics; of Puritan antecedents, and religious training. In the mill they were treated kindly, and, although their hours were long, they were not overworked. A feeling of real, but respectful, equality existed between them and their employers, and the best hands were often guests at the houses of the mill owners or ministers of religion. They lived in great boarding-houses, kept by women selected for their high character, and it is of these industrial families, and of their refined life, that observers like Dickens, Lyell, and Miss Martineau spoke with enthusiasm. The last writer has made us acquainted, in her “Mind among the Spindles,” with the height to which intellectual life once rose in Lowell mills, before the wave of Irish emigration, following on the potato famine, swept native American labor away from the spindles. The morality of the early mill-girls, again, was practically stainless, and, strict as the rules of conduct were in the factories, these were really dead letters, so high was the standard of behavior set and sustained by the mill-hands themselves.

Such was the character of native American labor, less than forty years ago, and such, almost, it still remains in those, now few, centers of industry where it has been little diluted with a foreign element. Nowhere is this so conspicuously the case as in Massachusetts and Connecticut, and especially in the western valleys of the former State, where important mill-streams, such as the Housatonic, the Naugatuck, and the Farmington, are lined with mills still largely manned by native Americans.

Aside from wages, which will be separately considered, the housing, education, sobriety, and pauperism of any given industrial community form together the best possible test of its social condition. In regard to the housing of labor, there is no more important fact to be discovered than the proportion of an operative population who possess in fee simple the houses in which they dwell. This proportion among the wage-earners of Massachusetts is remarkably high, one working man in every four being the proprietor of the house in which he lives. Of the remaining three-fourths, 45 per cent. rent their houses, and 30 per cent. are boarders. With regard to inhabitancy, the average number of persons living in one house in Massachusetts is rather more than six, while the average number of the Massachusetts family is four and three quarter persons. Hence, lodgers being excepted, almost every operative family in this State lives under its own roof, while one fourth of all such roofs are owned by the heads of families dwelling therein.

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I leave, for a moment, the agreeable task of describing one of these homes of native American labor, and pass on to the question of education, whose universality among native Americans is perhaps most vividly illustrated by the following facts. Of 1,200 persons born in Massachusetts, whether of native or foreign parents, only one is unable to read or write, while four Germans and Scotch, six English, twenty French Canadians, twenty-eight Irish, and thirty-four Italians, out of every 100 emigrants of these nationalities respectively are illiterate. The total number of public, elementary, and high schools in the United States is 225,800, or about one school for every 200 of the entire population, and one for, say, every fifty of the 10,000,000 pupils who attended school during the census year of 1880. Finally, referring once more to Massachusetts, there are nearly 2,000 free libraries in this single State, or one to every 800 inhabitants, and these, together, own 3,500,000 volumes, and circulate 8,000,000 of volumes annually.

With regard to sobriety, it is well known that local option succeeds in closing the liquor saloons in very many operative American towns, and with the happiest results. The county of Barnstaple in Massachusetts, for example, with a population of 32,000 souls, and having no licensed liquor saloons, yields a crop of only three convictions per annum for drunkenness. The county of Suffolk, on the other hand, with a population of nearly 400,000, and a license for every 175 of its inhabitants, acknowledges one drunkard for every 50 of its population. The labor in one case is nearly all native; in the other, largely foreign.

It is almost, if not quite, impossible to obtain the statistics of pauperism in America. The “indoor” poor, as paupers in almshouses are called, can be found and counted with comparative ease, but how can the outdoor paupers be found? It is no use inquiring for them from door to door, and the poor-master’s disbursements are so limited in amount that his bills for pauper relief become mixed up with other items, so that they cannot be separately stated. The total number of paupers resident in American almshouses is 67,000, or about one in every 70,000 of the whole population. In England, we have still one pauper in every fifty thousand of the population. Such being the more important aspects of native American labor, as displayed by the statistician, it is time for the social observer to give his account of a typical American artisan's home.

We are at Ansonia, in the Naugatuck valley, one of the chief towns of "Clockland," where, within a radius of twenty miles, watches and clocks are made by millions and sold for a few shillings apiece. Our friend Mr. S. is an Ansonia mechanic who occupies a house with a basement of cut stone and a tasteful superstructure of wood, having a wide veranda, kitchen, parlor, and bed-room on the ground floor and three bedrooms above. The house is painted white, adorned

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with green jalousies, and surrounded by a well-tilled quarter acre lot. Its windows are aglow with geraniums, and from its veranda we glance upward to the wooded slopes of the Green Mountain range, and downward to the River Naugatuck, whose blue mill-ponds look like tiny Highland lakes surrounded by great factories. Within, a pleasant sitting-room is furnished with all the comforts and some of the luxuries of life, the tables are strewn with books, and the walls decorated with pretty photographs. Mr. S.'s wife and daughter are educated and agreeable women, who entertain us, during an hour's call, with intelligent conversation, which, turning for the most part on the events of the War of Independence, is characterized by ample historical knowledge, a logical habit of mind, and a remarkable readiness to welcome new ideas. No refreshments are offered us, for no one eats between meals, and, in private houses, as in the public refreshment rooms, where native labor usually takes its meals, nothing stronger than water is ever drunk. Such are the homes of men whom I would distinguish as "American" artisans, and such, also, are those of many foreign workmen who have been long under native influence.

It is not in the valleys of Massachusetts, however, that the greatest manufacturing cities of the Union are to be found, the towns already referred to containing usually only a few thousand inhabitants, and being still, for the most part, rural in their surroundings. They are, indeed, the fastnesses, so to speak, to which the Yankee artisan has retired, after having been almost literally swept out of the great manufacturing cities by successive waves of emigrant labor, chiefly of Irish and French-Canadian nationality. To these great cities we must now turn for examples of a condition of operative society which contrasts most unfavorably with that which has already been sketched; it being, meanwhile, understood that a penumbral region, of more or less mixed conditions, graduates the brightness of the one into the darkness of the other picture.

The city of Lowell, whose brilliant past is so well known, exemplifies, on that very account, better than any other manufacturing town in the States, the character of recent alterations in American labor conditions. The mill-hands, formerly such as I have described them, have been almost entirely replaced by Canadians and Irish, who have given a new character and aspect to the Lowell of forty years ago. "Little Canada," as the quarter inhabited by the former people is called, exhibits a congeries of narrow, unpaved lanes, lined with rickety wooden houses, which elbow one another closely, and possess neither gardens nor yards. They are let out in flats, and are crowded to overflowing with a dense population of lodgers. Peeps into their interiors reveal dirty, poorly furnished rooms, and large families, pigging squalidly together at meal times, while unkempt men and slatternly women lean from open windows, and scold in French, or chatter with crowds of ragged and bare-legged children, playing in the gutters.

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The Irish portion of the town has wider streets, and houses less crowded than those of “Little Canada,” but is, altogether, of scarcely better aspect. Slatternly women gossip in groups about the doorways. Tawdrily dressed girls saunter along the sidewalks, or loll from the window-sills. Knots of shirt-sleeved men congregate about the frequent liquor-saloons, talking loudly and volubly. No signs of poverty are apparent, but everything wears an aspect of prosperous ignorance, satisfied to eat, drink, and idle away the hours not given to work. Such is the general aspect of operative Lowell to-day; but some of the old well-conducted boarding-houses remain, sheltering worthy sons and daughters of toil. Similarly, the outskirts of the city are adorned with many pretty white houses, where typical American families are growing up amid wholesome moral and physical surroundings, and enjoying all the advantages of schools, churches, libraries, and free institutions which the Great Republic puts everywhere, with lavish profuseness, at the service even of its least promising populations.

Concerning the Lowell mill-hands of to-day, I prefer, before my own observations, to quote from an article entitled “Early Factory Labor in New England,” written by a lady, herself one of the early mill-girls, and published in the “Massachusetts Labor Bureau Keport for 1883.” She says:

“Last winter, I was invited to speak to a company of the Lowell mill-girls, and tell them something of my early life as a member of their guild. When my address was over, some of them gathered round and asked me questions. In turn, I questioned them about their work, hours of labor, wages, and means of improvement. When I urged them to occupy their spare time in reading and study, they seemed to understand the need of it, but answered, sadly, ‘We will try, but we work so hard, and are so tired.’ It was plain that these operatives did not go to their labor with the jubilant feeling of the old mill-girls, that they worked without aim or purpose, and took no interest in anything beyond earning their daily bread. There was a tired hopelessness about them, such as was never seen among the early mill-girls. Yet they have more leisure, and earn more money than the operatives of fifty years ago, but they do not know how to improve the one or use the other. These American-born children of foreign parentage are, indeed, under the control neither of their church nor their parents, and they, consequently, adopt the vices and follies instead of the good habits of our people. It is vital to the interests of the whole community that they should be brought under good moral influence; that they should live in better homes, and breathe a better social atmosphere than is now to be found in our factory towns.”

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The city of Holyoke, another great cotton center, having 23,000 inhabitants, is in some respects the most remarkable town in the State of Massachusetts. It was brought into existence, 35 years ago, by the construction of a great dam across the Connecticut River; and, around the water power thus created, mills have sprung up so rapidly that the population, whose normal increase is eighteen per cent. every ten years in Massachusetts, has doubled, during the last decade, in Holyoke. But eighty out of every 100 persons in the city are of foreign extraction, the prevailing nationality being French-Canadian, a people who are so rapidly displacing other operatives, even the Irish themselves, in the manufacturing centers of New England that they must not be dismissed without remark.

The Canadian-French were recently described in a grave State paper as a “horde of industrial invaders,” and accused of caring nothing for American institutions, civil, political, or educational; having come to the States, not to make a home, but to get together a little money, and then to return whence they came. The parent of these immigrants is the Canadian *habitan*, a peasant proprietor, farming a few acres, living parsimoniously, marrying early, and producing a large family, who must either clear the soils of the inclement north, or become factory operatives in the States. They are a simple, kindly, pious, and cheerful folk, with few wants, little energy, and no ambition; ignorant and credulous, Catholic by religion, and devoted to the priest, who is their oracle, friend, and guide in all the relations of life. Such are the people—a complete contrast with Americans—who began, some twelve years ago, to emigrate to the mills of New England. They came, not only intending to return to their own country with their savings, but enjoined by the Church to do so. Employers, however, soon found out the value of the new comers, and Yankee superintendents preferred them as operatives before any other nationality, not only on account of their tireless industry and docility, but because they accepted lower wages, and kept themselves clear of trade-union societies. Thus, finally, it has come about that nearly 70 per cent. of the cotton operatives at Holyoke are of French-Canadian origin, and the social condition of all these people is precisely similar to that which has already been described as characterizing the inhabitants of “Little Canada” in Lowell.

It has already been said that the average rate of inhabitancy is six persons per house in the State of Massachusetts, but the presence of the French in Holyoke actually doubles the inhabitancy of the whole town, with what effect upon their own special quarter may easily be imagined. Probably nowhere in Europe could there be found more crowded houses, and worse physical conditions of life, than in the quarters inhabited by certain alien operatives in many manufacturing towns of the United States.

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Sharp contrasts as they are, these sketches fairly picture the heights and depths of industrial conditions in a region which, as I would again remind you, contains nearly one-half of all the factory operatives in America. More than this, while the States in question would yield to no others their claims to represent advanced civilization, Massachusetts, the creation of the Puritan refugees, and the cradle of American independence, stands confessedly at the head of all her sister States for enlightened philanthropy. There are no greater lovers of right, honorers of industry, and friends to education in the world than its people, yet the present social condition of Holyoke and of Lowell, as of many other manufacturing cities, would have shocked all America thirty years ago, and been impossible less than half a century back. It is time we should ask, How is America going to treat a problem, formerly the danger and still the perplexity of Europe, for which democratic institutions have failed to furnish the solution once confidently, but unfairly, expected from them?

The State, the Church, and the School are all doing their best to prevent the lapse to lower conditions which seems to threaten labor in the States, each of them trying their utmost to “make Americans” of alien laborers, by means of the political, religious, and educational institutions of the country. How inadequate these unaided agencies are for the accomplishment of their gigantic task is nowhere so clearly realized as in the common, or free, schools of the States. These, in districts such as I have distinguished as “American,” are filled with boys and girls, of all ages from five to eighteen, whose appearance and intelligence bespeak high social conditions. Whatever the occupation which these young people may ultimately adopt—and all of them are destined for work-a-day lives—an observer feels quite sure that they are more likely to raise the character of their several employments, than to be themselves degraded to lower social levels, on quitting school.

But no similar confidence in the future of American labor is engendered by visits to the schools where sits the progeny of alien labor. In the case of the Canadians, indeed, parents and priests alike bend all their energies to the establishment of “parochial schools,” which, if they forward the cause of the Church, do little for education in the American sense of requiring good citizens, even more than good scholars, at the hands of the national teachers.

The primary schools of great industrial towns, such as Fall River, the Manchester of America, are filled, to quite as great an extent as similar schools in Europe, with ignorant, ragged, and bare-footed urchins. These children are, indeed, no less well cared for and taught than their Yankee fellows, and one cannot sufficiently admire the energy and enthusiasm with which school-teachers generally endeavor to “make Americans” of their stolid and ragged little alien charges. In these cases, however, where often the children have had no schooling at all before they are old enough to work, it is quite clear that the school cannot do all that is required to raise the labor of to-day up to the levels it occupied in the past. And, if the school itself is ineffective in this regard, how much more so must be the Church, to which immigrant youth is a comparative stranger; or those democratic institutions which are based, to quote the words of Washington himself, upon "the virtue and intelligence of the people."

Whether the present condition of labor in America will ever again be lifted to the levels of the past depends, in truth, less upon the State, the Church, and the School, than upon the part which the American employer is taking or about to take in this question. It is impossible for any unprejudiced observer to be long in the States, and especially in the New England States, without coming to the conclusion that a large number of employers are very anxious about the character of the labor they employ, and willing to assist to the utmost of their power in improving it. In spite of the love of money and luxury which is so conspicuous a feature of certain sections of American society, a high ideal of the proper function of wealth has arisen in the States, where large fortunes are chiefly things of recent date, among large and influential classes having an enlightened regard for the best welfare of the country. This regard finds expression now in the establishment of a factory, managed with one eye on profits and another on the elevation of the artisan, and now in the endowment of free libraries or similar institutions, offering opportunities of improvement to all.

To give only a few instances of the former movement: Mr. Pullman, the great car-builder, has recently established, on Lake Calumet, a vast system of workshops and workmen's homes, a description of which reads like a chapter from More's "Utopia." The Waterbury

Watch Company has lately built a factory, employing 600 hands, on similar lines to those of Mr. Pullman. Cheney Brothers' silk mills at South Manchester remain now, after Irish labor has entirely taken the place of native hands, at almost the same high level as that which, in common with Lowell, they held forty years ago. Messrs. Fairbanks, of St. Johnsbury, in Vermont, conduct a large establishment, where every married *employe* owns a house in the village, almost an Eden for beauty and order, which has grown up around these remote but remarkable scale works. Similarly, the Cranes at Dalton, in Massachusetts; Messrs. Brown, Sharpe and Co., at Providence, Rhode Island; Mr. Hazard at Peacedale, Narragansett; and last, not least, Col. Barrows, at Willimantic, in Connecticut, have all succeeded in restoring the past conditions of native American labor among operatives, now, for the most part, of alien origin.

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I wish that time permitted me to sketch, however briefly, the mills to which I have last alluded. It must suffice to say that the devoted labors of Col. Barrows, President of the Willimantic Thread Co., have succeeded in creating, out of Irish labor, social conditions of industrial life which approach ideal perfection as nearly as the work of imperfect man can possibly do. And, better still, the high morality and intelligence of Col. Barrow's 1,600 operatives, the comfort and seemliness of their homes, the cleanly and cheerful character of the mill work, even the refinements of the music and art schools attached to the mill, can be proved, by hard figures, to be paying factors in the undertaking, viewed from a purely commercial standpoint.

So far, I have endeavored to show that a great contrast exists between what once was and now is the condition of factory labor in America. I have, further, described certain survivals of an earlier and happier state of things, and indicated the forces now at work tending to lift the Holyoke of to-day, for example, to the social levels of old Lowell. I have given my reasons for believing that the democratic institutions of America are incapable, unaided, of accomplishing such a task as this charge implies, and concluded that its accomplishment depends mainly on the action of the American employer. What this action as a whole, and what, therefore, the future of labor in America is likely to be, I confess myself in grave doubt—doubt from which I turn, with something like a sense of relief, to discuss those economical considerations affecting wage-earners which have hitherto been made to give place to social inquiries.

We have now to ask what are the wages of labor in the States, their relation to the cost of subsistence, and to wages and cost of subsistence in our own country? Finally, I shall briefly consider certain propositions of the American political economist which are so inextricably mixed up with the question of labor and wages in the

States that it is impossible to discuss the one without taking some note of the other.

Until quite recently, no complete investigation, bringing the rates of wages paid in industries common to the United States and European countries, has ever been made, although the results of such an investigation have been constantly and earnestly called for both by the press and people of America. Permit me to remark, in passing, that we know little in this country of the desire for full, trustworthy, and accessible statistics, concerning all matters of national interest, which dominates the public mind of America; and as little of the willingness with which American citizens of all classes place the particulars of their private business at the service of the statistician. This desire for statistical bases whereon the statesman and economist may build, is vividly illustrated by that publication, perhaps the most wonderful in the whole world, entitled a “Compendium of the Census

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of the United States," issued with every decade. These volumes, accessible to everybody, and arranged with marvelous skill and lucidity, offer to the social observer a complete, accurate, and suggestive survey of every field comprised within the vast domain of the national interests. An evening's address would not more than suffice to indicate the scope and appraise the value of this work, which is a mine wherein, the ore ready dressed to his hand, the politico-economic or industrial essayist might work for years without exhausting its riches.

But the United States Census does not treat specifically of wages and subsistence, and it is to the Massachusetts Labor Bureau that we must again turn for such information as we now require. Dr. Edward Young, indeed, the late chief of the United States Bureau of Statistics, published an elaborate work upon this subject in 1875, but his comparisons as to the relative cost of living in America and Europe, good in themselves, are rendered of little value by the absence of such statistics as would give the true percentage of difference between American and foreign wages. Several elaborate wages reports were also published between 1879 and 1882, which, while they gave the American side of the question with great fullness, presented foreign wages very incompletely.

Always, however, impressed with the importance of making an accurate comparison between wages and the cost of subsistence on the two sides of the Atlantic, but unable to undertake a very wide inquiry with the funds at its disposal, the Massachusetts Bureau determined, in the fall of 1883, upon reducing to narrower limits than heretofore the field of investigation. Instead of America and Europe, Massachusetts and Great Britain were selected for comparison, the former as the chief manufacturing State of America, the latter as her leading competitor.

With this view, a number of agents were sent to gather personally, from the pay rolls of American and English manufactories, the rates of wages paid in twenty-four of the leading industries which are common to the two districts respectively. It was, at first, sought to extend the inquiry to thirty-five different industries, a number which would practically have covered the whole ground, but nine of these were finally abandoned for want of sufficient British information.

It is a perfectly easy thing, as already indicated, to gather wage or other statistics in the counting-houses of Massachusetts manufactories, but quite a different matter when a collection of similar information is attempted in this country, where most proprietors are unwilling, and many altogether refuse, to give any information regarding their industries.

The following table, of which an enlarged facsimile, marked A, appears on the wall, specifies the twenty-four industries from which the returns in question were made, and the number of establishments making such returns in each industry in either country:

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Table A.

Industries.	Massachusetts.	Great Britain.	Total
Agricultural implements	4	1	5
Artisans' tools	3	4	7
Boots and shoes	18	2	20
Brick	3	1	4
Building trades	32	24	56
Carpetings	1	1	2
Carriages and Wagons	11	3	14
Clothing	10	4	14
Cotton goods	10	9	19
Flax and jute goods	2	3	5
Food preparations	5	2	7
Furniture	11	1	12
Glass	1	3	4
Hats (fur wool and silk)	3	2	5
Hosiery	5	3	8
Liquors (malt and distilled)	10	1	11
Machines and machinery	12	15	27
Metals and metallic goods	25	13	38

Printing and publishing	12	7	19
Printing, dyeing and bleaching etc	3	4	7
Stone	10	1	11
Wooden goods	12	1	13
Woolen goods	4	2	6
Worsted goods	3	3	6
	210	110	320

Thirty-two cities in Massachusetts, and twenty-six in Great Britain, were visited in search of returns, of which almost all our great industrial centers yield their quota.

It being, of course, impossible to obtain wage returns for all the *employes* of these various industries in either country, the investigation aimed at covering at least 10 per cent. of such totals, and, in the case of Massachusetts, succeeded in getting returns for 36,000 hands, or 13 per cent. of the whole number of artisans employed in the twenty-four industries examined. Great Britain, on the other hand, made returns for about half that number of hands, but their proportion to the totals employed cannot be similarly stated, first, because we have here no specific industrial census, and, second, because many of the English returns were made for an indefinite number of *employes*.

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The comparison was made in the following way: For each of the twenty-four industries, a table, consisting of four sections, was constructed, *viz*., “Occupation,” “Aggregation,” “Recapitulation,” and “Comparison.” The first gave the names of the various branches of each industry, classifying these as minutely as possible, because the names indicating subdivisions of labor are, generally, so different in the two countries that the actual “matching” of occupations, desirable for a perfect comparison, is impossible. The second, or “Aggregation” section, brings the various occupations in the same industry into juxtaposition, and supplies opportunities for direct comparison. The third, or “Recapitulation” section, is drawn from the “Occupation” section, and shows the number of men, women, young persons, and children for whom wages are given; whether these are paid by the day, or by piece; and whether the wage returns show the actual amounts paid to a definite number of *employes*, or an average wage for a definite or an indefinite number of *employes*. The fourth, or “Comparison” section, brings the highest, lowest, and general average weekly wages into final comparison.

The first three sections of the table, being either simply enumerative or collective in character, are easily understood without illustration, but an example of the “Comparative” section, marked Table B, hangs on the wall, and shows all the final comparisons at a glance.

Table B.

	1	2	3	4
Classification.	Massac- husetts.	Great Britain.	Massac- husetts.	Great Britain.

Average highest weekly wage paid to--	dols.	dols.	dols.	dols.
Men	37.00	13.39	25.41	11.36
Women	5.50	...	8.57	4.10
Young persons	7.00	3.65	6.94	3.04
Children	5.70	...	4.64	1.05
Average lowest weekly wage paid to--				
Men	7.60	3.21	7.09	4.72
Women	5.00	...	4.62	2.27
Young women	4.50	1.46	4.26	1.66
Children	3.00	...	3.09	.60
Average weekly wages paid to--				
Men	12.04	8.07	11.85	8.26
Women	5.12	...	6.09	3.37
Young persons	5.76	2.52	5.10	2.40
Children——	5.31	...	3.81	.79

The two first columns of the table are simply illustrative of the method applied to a single industry, exhibiting the highest average, lowest average, and average weekly wages, whether to men, women, young persons, or children, in the particular business of "machine-making," together with the general average wages paid to all the *employes* in such industry. The general average weekly wages in this industry are thus shown to be 45.6 per cent. higher in Massachusetts than in Great Britain.

The 3d and 4th columns of the table consolidate all the twenty-four industries, and yield, in similar terms, as in the case of machine-making, an average comparison applying to the whole group of industries under examination, giving, as a grand result, that the general average weekly wages of Massachusetts are higher by 48.28 per cent. than those of Great Britain.

It is, however, explained that the British wage returns were made in three different ways, *viz*., for a definite number of *employes*, by percentage returns, and by general returns; both of the latter being for an indefinite number of *employes*. Where more than one wage-basis was given, the highest figure was used in the calculations, and, this being the case in eighteen out of the twenty-four industries, its effects on the grand result are considerable; for, by crediting Great Britain with the *average* instead of the *high* weekly wage, the average percentage in favor of Massachusetts rises from 48.28 per cent. to 75.94 per cent.

In order truly to indicate the higher percentage of average weekly wages in Massachusetts, we must, therefore, agree upon a figure somewhere between these two extremes, *viz*., that of 48.28 per cent., derived from tables in which Great Britain is credited with the high wage, and that of 75.94 per cent., derived from those tables in which she is credited with the average of the returns made upon the different bases. The mean of these figures is 62.11 per cent., which is considered to be the result of the investigation, and may be formulated as follows: The general average weekly wages paid to *employes* in twenty-four manufacturing industries common to Massachusetts and Great Britain is 62 per cent., higher in the former than the general average weekly wages paid in the same industries in the latter country.

But the question of wages forms only one side of the working man's account; on the other stands the cost of living, and no comparisons of prosperity, in given industrial communities, are of any value which omit to take into consideration the relative ease with which such communities can procure the means of subsistence. Table C presents a summary of prices, gathered in 1883, of the chief items in a working man's expenditure, and their cost in Massachusetts and Great Britain.

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Table C.

Articles.	Percentage higher in Mass.	Percentage higher in Great Britain
Groceries	16.18	—
Provisions	—	20.00
Fuel	104.98	—
Dry goods	13.26	—
Boots and shoes	42.75	—
Clothing	45.06	—
Rents	89.62	—

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Having agreed that wages are probably 62 per cent. higher in Massachusetts than in Great Britain, it would be easy, if we could ascertain what proportion of a working man's income is spent respectively in groceries, provisions, clothing, *etc*., to determine what advantage an operative derives from the higher wages of the United States. Dr. Engel, the chief of the Prussian Bureau of Statistics, puts us in possession of this information, and, as the result of a laborious inquiry, has formulated a certain economic law which governs the relations between income and expenditure. From him we learn (see Table D) that:

Table D.

A working man with an income of L60 per annum spends as follows:

Per cent.
of income.
Shillings.
/ meat....
248
1. On subsistence 62 or \ groceries

496
2. " clothing 16 "
192
3. " rent 12 "
144
4. " fuel 5 "
60
5. " sundries 5 "
60

Total shillings
1,200
Or
L60

Now, referring to Table C, it will be seen that the same man's expenditure in America would be:

Shillings.
S.

1. On subsistence / meat....
248 — 20 p.c. = 198.4
\ groceries 496 + 16 "
= 575.3
2. " clothing 192 + 45 "
= 278.4
3. " rent 144 + 89 "
= 272.1
4. " fuel 60 + 104 "
= 122.0
5. " sundries 60 + 50 "
= 90.0

Total
1,536.2
Or L76
16s.

In other words, a workman earning L60 per annum in Great Britain would receive L99, or 62 per cent. more wages in the States, but living there would cost him L77, or L17 more than here, giving him a net advantage of only 28 per cent., instead of 62 per cent., derived from living and working in America.

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But this result does not exhaust the question. The standard of life is very different among working men in the States and in Great Britain, and the almost inexhaustible statistics of the report, already so often quoted, enable us to gauge this difference with accuracy. It has been proved, by a recent investigation, whose details we need not follow, that the expenditure of working men's families, of similar size, in Massachusetts and in Great Britain, stand to each other in the ratio of 15 to 10. By introducing this new factor into our calculations, we find that a man who spends L60 per annum in England would spend L90, instead of L77, per annum in the States, paying American prices for subsistence, and living up to American standards. In other words, he would be a gainer to the extent of only L9 per annum by living and working in the United States. Finally, if we presume that 48 or 50 per cent., rather than 62 per cent., measures the higher wages of Massachusetts, the same man's increased wages would be L90 instead of L99, and he would-neither lose nor gain in money by becoming an American citizen, and adopting American habits.

That these conclusions agree with those rough and ready practical illustrations which, without being scientific, are generally trustworthy, let the following story evidence.

Some years ago, a skillful moulder, in my then firm's employ, left us for the States, where he permanently settled. After a long absence, he returned for a few weeks' holiday, when I asked him whether he earned higher wages and found life more agreeable in America than in England. "Well, as to money" was his reply, "I think, taking all things into consideration, I did about as well in the old shop as I do now; but, socially speaking, I am somebody there, while here I am only a moulder." Social advantage, indeed, probably measures almost all the difference between the position of a skilled factory operative in the States and in England.

Let me not seem, however, to undervalue that difference. Statistics, after all, do not dominate human nature; on the contrary, human nature determines the statistician's figures. Every artisan emigrant to America gains opportunities of advancement of which his European fellows know nothing. If he have brains, the way to success is open there, while it is practically barred to anything short of genius for men of his class in Europe. Our Australian colonies, where unskilled labor can earn 7s. 6d. a day, and live for a trifle, are, indeed, a paradise for the mere wage-earner, who can scarcely help becoming also a wage-saver; but America is the country which, with wage conditions such as I have attempted to portray, still offers the best possible opportunities of success, and even of great careers, to clever working men, and especially to clever mechanics. That man, however, is not worthy of a home in the great republic, who does not appreciate the higher social levels at which native labor desires to live, who is not anxious to make the most of the advantages which democratic institutions offer him, who does not, in short, ardently desire to become a "good American."

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There remains the question already alluded to as inextricably bound up with American labor problems: How does the American tariff affect wages? The idea that these are determinable by the tariff is the corner stone of protection in the States. The artisan has been so sedulously educated to believe that the chief object of import duties is to protect him from falling into a ruinous competition with what is called the "pauper labor of Europe," that no movement on the part of workmen in the direction of free trade is ever likely to arise in America. I am not now about to argue the question of protection, except in so far as it relates to labor; but it may be remarked, in passing, that internal competition, rather than the people, is the enemy from whom the tariff will probably receive its death blow in the future. Protection will ultimately break down by its own weight in the States. Production already exceeds demand, the cry for a "wider market" and for "raw materials free" is in every manufacturer's mouth; and if America upholds her protective legislation too long, the produce of her factories and mills will, by and by, force its way, in spite of the tariff, into the open markets of the world, but it will be through the gate of national suffering. Few people in this country are, I think, aware of the extraordinary fervor with which the doctrine that protection benefits labor is preached in the States. We are ourselves accustomed to hear the question of free trade argued only from the economic standpoint, but this is by no means so commonly the case in America. I shall try, by paraphrasing certain recent addresses of an able personal friend and enthusiastic protectionist, to illustrate the position taken by those persons who advocate the tariff, not upon economic grounds, but in the avowed interests of labor.

Referring to the words "Free Trade," the speaker in question begins by asking, "What is the essential nature of that which we call trade?"

And answers himself as follows:

"The grim, ugly fact is that trade is a fight, the markets are battle fields, the traders are gladiators, carrying on a true war around questions of values, with no care whether the opposing party or the community at large can afford that the trade is made. This contest is always going on, whether a lady buys a pair of gloves, or a syndicate corners Erie. Antagonism is so fixed an element of trade, and so often defeats the object it blindly follows, as to make laws which seek to mitigate the ferocity of the struggle as welcome to the far-sighted man of business as they are to the foredoomed victims of this relentless warfare."

On the other hand, competition is said to be a—

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“Wonder worker in developing energy in the strongest individuals, and massing wealth in masterful states; but, since competitive trading can never be wholly beneficent, it should be strictly controlled, in the interests of the toiling millions, who are too weak successfully to oppose its attacks. The results of forcing on the naturally weak, by means of competition, hard and unequal bargains which are evaded by the strong, are appalling in their magnitude, dividing whole peoples permanently into castes, rich and poor, injuring the former by excess, and the latter by deprivation, making a nation strong in the trading instinct, and rich in accumulated wealth, but weak and poor in all its other parts. This abuse is saddest of all when, failing to be recognized as an evil, the doctrines of free trade are wrought into the policy and social life of a people.”

Protective remedies for this state of things are introduced as follows:

“Wherever the value of competition has been fully recognized, but supplemented by wise control of its energies, the results are excellent. This fact forms the foundation of our protective laws, whose very name ‘protective’ implies assailants; those hard bargains, to wit, driven on the fighting side of trade, under the motto of ‘let the fittest survive.’ When a small army is attacked by a large one, it covers itself by earthworks. Similarly, where there are sheep, and wolves abound, the farmer puts up fences which effectually protect his flock; and, in the same way, tariffs are ‘forts,’ whence the artisan may hope successfully to defend himself against the attacks of his powerful and unscrupulous enemy, capital; or they may even be considered as a pistol, which a little fellow points at a big bully who threatens him with a thrashing.”

Such are the arguments which are urged with great fervor, and immense effect, upon the American artisan, who fully and firmly believes that protection is the only agent capable of lifting his lot above those, dreaded levels at which the “pauper labor of Europe” is universally believed to live.

The simple answer to all this rhetoric appears to be that, while it might be valid as an indictment of the competitive system as a whole, it is valueless when directed against a part of that system only. Advocates who are not prepared to say that every bargain shall be controlled by beneficence, and who distinctly admire the chief results of competition, cannot logically demand that labor, alone of all salable commodities, shall be bought and sold on altruistic principles.

In what immediately precedes, I have endeavored to indicate the character of the pleadings which make American artisans universally supporters of the tariff, and we must now return to the question, What, after all, is really the effect of protection on wages in America? I answer that no legislative schemes can add to, although they may injure, the material resources of a state. Capital can only support the labor for which the annual harvest of such resources pays, and all that legislation can do is artificially to divert labor and capital from directions which they would take under the influence of natural laws.

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America is selling, at the present time, about L160,000,000 worth of food and other raw products in Europe. These, together, represent her chief branch of business, in which nearly fifty per cent. of her population is engaged, and all this merchandise is sold in the free trade markets of the world. Wages in America, therefore, cannot possibly be regulated by the tariff, because, whatever wages can be earned by men engaged in the production of agricultural products—the prices of which are fixed in Liverpool—must be the rate of wages which will substantially be paid in other branches of business. Wages, like water, seek a level; if manufacture pays best, labor will quit agriculture; if agriculture pays best, manufactures will decline, and agriculture progress.

A glance at the condition of industrial society in America vividly illustrates this conclusion. Any man, with a few dollars and a strong pair of arms, can win far greater rewards from the soil than he could possibly obtain by the same effort in Europe. His wages are high, because the grade of comfort to be obtained from the land by means of a little labor is high, and the artisans' wages must follow suit, if men are to be tempted from the field into the workshop. American politicians, however, would have us believe that American labor owes its prosperity to taxation; in other words, that what the immigrant seeks is not the rich prizes offered him by a free and fertile soil, but the blessings which flow from a tariff that adds an average 40 per cent. to the cost of everything he needs except food.

One more illustration, and I have done. Upon the wall hangs a diagram which shows the movements of American wages, of English wages, and of the tariff from 1860 to 1883. I have already argued that a tariff cannot determine wages, and the diagram affords positive proof that it has not determined them in America, as between 1860 and the present time. On the contrary, their movements are evidently due to the same causes as have influenced wages here during this period, while it is certainly remarkable that they have fallen sooner, fallen lower, and recovered less completely in America, where industry is "protected," than in Great Britain, were it is "unprotected."

Shortly to recapitulate all that has been advanced, I have endeavored to show:

1st. That a great change has occurred in the social condition of labor in the United States during the last forty years, and that, spite of all the existing agencies of improvement, it is doubtful whether the working classes of America are not, at the present moment, falling still further from those high ideals of operative life which once so brilliantly distinguished the United States from European countries.

2d. That, although wages are probably some 60 per cent. higher in the chief manufacturing districts of America than in Great Britain, yet an English artisan would find himself little richer there than at home, after paying the enhanced prices for subsistence, and conforming to the higher standard of life which prevails in the States. At the same time, his whole social position and opportunities of advancement would be immensely improved.

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3d. I have tried to demonstrate that the tariff, to which the higher wages of America are so confidently attributed, has really no influence whatever upon them, and that it is not therefore an engine, such as it is glowingly represented to the American artisan, constructed for the purpose of raising his lot above that of the so-called “pauper labor of Europe.” Any inquiry into the character of the work really accomplished by the engine in question would lead me into regions of controversy forbidden in this room.

Finally, if I am asked why, in a review of American labor and wages, I have said nothing of trade unionism on the one hand, and of co-operative production on the other, I can only answer that to have introduced these among so many other interesting, but subsidiary, subjects which crowd around questions of labor and wages, would have doubled the volume of this address, and more than halved the patience with which you have kindly listened to it.

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General average weekly wage paid to all *employes*	11.75	8.07	10.32	6.96
Result: General average weekly wages higher in Massachusetts by per cent	45.60 per cent.		48.28 per cent.	