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REPORTS OF THE UNITED STATES COMMISSIONERS.

THE PRODUCTION OF IRON AND STEEL IN ITS ECONOMIC AND SOCIAL RELATIONS

BY

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CONTENTS.

SECTION I.

IRON AND STEEL.

BESSEMER STEEL IN AUSTRIA AND PRUSSIA.

Conditions of production similar to those of Sweden—Analyses of the irons and slags—Method of testing the quality—Prices of the steel in various forms.—pp. 81-85.

APPENDICES.

ILLUSTRATIONS.

IRON AND STEEL.

SECTION I.

IRON AND STEEL.

IRON ORES, ROLLED GIRDERS, PLATES, AND RODS.

In the general arrangement of the Universal Exposition of 1867, iron and steel, as products of industry, were placed in the fortieth class of the fifth group. In the distribution of the work of the Commission of the United States, made in conformity with the directions of the Secretary of State, a committee was constituted on "Metallurgy and the extractive arts in general," and to this committee was subsequently assigned, by resolution of the commission, the duty of reporting on "Minerals, as raw materials in the economic arts." The committee consisted of Commissioners Hewitt, D'Aligny, and J. P. Lesley. To Commissioner Lesley was assigned the task of reporting upon "Mining machinery and processes of mining;" to Commissioner D'Aligny, on "Minerals, as raw materials in the economic arts, and on the metallurgy of the precious metals;" and to Commissioner Hewitt "On the production of iron and steel in its economic and social relations."

In the preparation of this report, in order to bring it within reasonable limits, the general principle has been adopted of attempting only to describe specimens of material, machinery, and processes of manufacture which differ substantially from the experience of the United States; thus presenting, as far as practicable, a purely *differential* report upon the iron and steel of the Exposition. The necessity for this course will be apparent from the mere statement that the catalogue of class forty includes 2,395 entries, of which the far larger portion are produced in the United States of equal quality, and by processes equally economical. The exhibition of the United States, however, was of so meagre a character that foreigners, judging from the lessons of the Exposition, would have come to the inevitable conclusion that the iron and steel industry of the United States is not entitled to the rank which it undoubtedly occupies in the metallic production of the world. The various ores mainly used in the manufacture of iron in the United States were indeed to be found among the minerals exhibited from the primitive regions of Lake Superior, New York, and New Jersey, while the brown hematites of Connecticut, Pennsylvania, and Alabama, together with the red fossiliferous ore of Tennessee and Alabama, and a brochure published by Mr. Haines, agent of the State of Alabama, were sufficient to call attention to the unequalled resources of the United States for the foundation of an iron industry which, under equal conditions as to the price of labor, would soon be in advance of that of any other nation whatsoever. A single piece of spathic ore, from Connecticut, and a few pieces of franklinite, from New Jersey, alone served to indicate the possession of the indispensable material upon which the production of Bessemer steel, as at present practiced, is based. A few pieces of pig iron from Lake Superior, from Wisconsin, Ohio, and Alabama, and some inconsiderable specimens of wrought iron, made from the Lake Superior and the Alabama pig, were the sole indications of an annual production of more than a million tons of iron. The only proof of the existence of any manufacture of steel in the United States was contained in a case of very beautiful specimens contributed by Park Brothers & Co., of Pittsburg, for which they received a silver medal. There was no evidence in the Exposition of our large and increasing product of bar iron, of the rolled girders—in the manufacture of which we preceded the world—of the cut nails, of which we enjoy almost a monopoly, and of the infinite variety of wrought and cast iron, in the skilful production of which we are not surpassed by the most advanced nations of Europe. On the other hand, there was a marked superiority in the products of the European makers designed for uses requiring difficult shapes—a requirement met in our country either by welding or riveting pieces together, and which in Europe, at the present time, seems to be almost universally supplied by material of such admirable quality as to admit of being forged or pressed into the most intricate and unusual forms. Such articles as deeply-dished boiler heads, steam domes, tube sheets, and even culinary vessels of every form and variety, and many other articles of fancy, designed merely as *tours de force*, such as cocked hats, and series of square domes raised from a flat plate, were exhibited, made from a single piece without weld or joint. Nor was this evidence of peculiar excellence confined to any one country. In France, the works at Le Creusot, Chatillon, and Commentry, and those of Messrs. Petin, Gaudet & Co.; in England, the Bowling and Low Moor Works, and those of the Earl of Dudley; in Prussia, the works of A. Borsig, near Berlin, and of Hoerde; and, in Austria, the imperial works at Neuberg, may be enumerated, among others, as having exhibited material of such remarkable quality as to open an entirely new field for the application of iron and steel.

Again, there was unmistakable evidence in the Exposition of the readiness of the European ironmasters to grapple with difficulties in the way of rolling shapes, from which at present the American maker would shrink. For example, Messrs. Petin, Gaudet & Co. (France) exhibited a rolled beam of the depth of 1 metre, (39⅜ inches,) in length 9.72 metres, (over 32 feet,) and weighing 2½ tons. They also exhibited another beam weighing 2.3 tons, 12 inches in height, and over 106 feet in length. The works of Chattilon and Commentry exhibited a beam 43½ inches in height, and with a 12-inch flange, but of very moderate length; but another beam was exhibited, about 100 feet in length, 9 inches high, weighing about fifteen hundred weight. The Burbach (Prussian) works exhibited a rolled beam 47 feet long and 15 inches in height. A careful observation, however, of the various structures in process of erection on the Continent, failed to show that these remarkable specimens of rolling had yet been brought within such limits of cost as to admit of their use in building. In the Exposition building itself, no rolled beams were to be found of a greater depth than 9 inches, and in the innumerable buildings which are being erected in Paris, and in which iron beams are invariably employed to the exclusion of wood, 4 inches, 6 inches, and 7 inches are the dimensions most generally employed. Thus far the construction of a fire-proof building in the United States is accomplished with less pounds of iron for a given strain per square foot than in France, and we have nothing to learn from the Exposition in this respect. But now that it has been found possible to produce beams of such large dimensions by the simple process of rolling, it is but reasonable to expect that the cost will be reduced as experience is gained, and that they will gradually replace the riveted girders, which even in the palace of the Louvre are invariably employed for spans of any considerable extent. It is proper, however, to call the attention of our American makers of rolled beams to the extraordinary specimens which we have described, and which it is understood are produced by the aid of the "universal rolling mill." Of this two forms were on exhibition, one in the pavilion of Chatillon (France) and the other in the Austrian department. The latter consists of four rolls, in two pairs, working at right angles to each other, a description of which, illustrated by engravings, can be found in Colburn's Journal (Engineering) for May 24, 1867. Of the mill at Petin, Gaudet & Co.'s no model was exhibited, and no description of it was given in the documents furnished to the commission.

By a personal visit to the works, however, the construction of the mill was seen to be very simple, and not remarkable for novelty. For each size of beam there is a pair of rolls, each having a working face at the middle of its length equal in width to the depth of the beam. The diameter of the roll at this part is very large, say 3 feet 6 inches, the body of the roll for the rest of its length being about 22 inches diameter. This formation of the rolls leaves a considerable space between the two, except where the working faces come together. In this open space is placed a pair of rollers, working on vertical axes fixed in stout movable frames, by which they can be brought into juxtaposition with that portion of the horizontal rolls which is of largest diameter. The pile used is somewhat thinner than the width of the flange to be produced, and of a width somewhat greater than the depth of the beam, and is so made up as to conform roughly to the final shape of the girder. As the main rolls are brought together, and form the trough in the beam, the friction rollers at the sides are also pressed towards the centre, and tend, by the pressure which they exert, to extend the flanges at the same time that the web is being drawn out by the main rolls. An offset is turned in the side of the large portion of the rolls to receive and form properly the flange as it is extended by the pressure of the friction rolls. The latter are worked each by a screw in a horizontal frame bolted to the side of the housing, the screw being provided with a ratchet lever, to be worked by hand. This enables the thickness of the flanges to be adjusted with precision. With this mill they have rolled girders of 40 inches height, 33 feet long, and feel confident that they could make them 90 feet in length. The essential features of this mill were all to be found in the first train for rolling beams, erected in 1853 at the Trenton Works, New Jersey, but in that case the axes of the driven rolls and of the friction rolls were at right angles to the mill of Petin, Gaudet & Co., which is probably a better working arrangement than the old train at Trenton. The Universal mill is not yet introduced into England, but forms the subject of an English patent now expired, and is undoubtedly destined to fill a very important place in the rolling of iron, and the American ironmaster cannot too soon avail of its advantages before impediments shall be put in its way by the issue of American patents.

Next to rolled girders, or perhaps even more remarkable than these, were the specimens of plate iron contributed from England, France, Germany, and Belgium. John Brown & Co., of Sheffield, exhibited a plate which, after being dressed up to square edges and ends, was 30 feet in length, 2 feet 6 inches in width, and 6 inches thick, weighing 11 tons 5 hundred-weight; and also a piece of a plate which in its original condition was 13 feet long, 6 feet wide, 13½ inches thick, and weighed 20 tons.

For the production of these enormous masses of iron the machinery is of the ordinary kind in construction, but of dimensions proportionate to the mass of iron to be handled. The size of the rolls is 3 feet, and the handling of the iron is accomplished with facility by the aid of steam cranes and of iron chains winding upon the rolls themselves, which are reversible by a clutch gearing, and make about 20 revolutions per minute.

Other plates of six inches in thickness and of various weights up to five tons were exhibited by the works of Chatillon and of Messrs. Petin, Gaudet & Co., (France,) and of Hoerde, (Prussia.)

Generally there may be said to exist a prevailing willingness and practice in the European works to handle iron in larger masses for every purpose than we do in the United States. For example, Belgium exhibited band iron three-fourths inches wide by 230 feet in length; Prussia exhibited sheet iron of 21½ gauge, 48 by 108 inches, and wire rods are frequently to be found in all the departments ranging from 30 to 50 pounds in weight, rolled in trains of the ordinary dimensions, and running at speeds no greater than we employ in the United States, for 15 pound billets. This is accomplished by keeping the billet in many more grooves at the same time than we are in the habit of doing, by an ingenious system of doubling the rods backwards and forwards. This same method is employed at Montataire, in France, and at other works for rolling braziers' rods, and even bar iron; and this not from the necessities of the order, but from choice, as a matter of economy. In this way one-inch bars of 100 feet in length are regularly produced, and this system, unknown in the United States, can doubtless be introduced with great advantage.

But the most remarkable specimen of rolling was in the English department, exhibited by Richard Johnson & Nephew, of Manchester, in the shape of a coil of No. 3 wire rods, weighing 281 pounds, in length 530 yards, rolled from a single billet. Also a coil of No. 8 wire weighing 200 pounds, 900 yards in length, and a coil of No. 11 wire weighing 95 pounds, in length 790 yards. These wonderful specimens of wire were not, however, produced in an ordinary mill, but were rolled in a machine invented by George Bedson, the manager of the Bradford iron works, in Manchester. This machine consists of rolls in thirteen pairs, placed one behind the other, instead of side by side, as usual, with guides connecting the successive pairs of rolls, and revolving at such relative rates of speed, that the billet being rolled receives the compressing action of the rolls all at the same time. The billet is fed from a long heating furnace at one end of the train of rolls, being charged at the end of the furnace furthest from the train. A Siemens' generator is used to supply the furnace with gas, so as to insure a uniform heat. The average product of the train is 11 tons per day, and the weight of the billets usually rolled is from 80 to 100 pounds. A comparison of the work for six months, with two old-fashioned trains also running in the same works, shows that the waste is reduced from $10\frac{1}{2}$per cent. to $6\frac{9}{10}$ per cent., and that the consumption of coal is reduced from 14 hundred-weight, three quarters, 25 pounds, to 8 hundred weight, and 18 pounds per ton, most of which saving is doubtless due to the use of Siemens' furnace, and not to the train; the advantages of the latter consisting in an increase of product of nearly one-half in the increased weight of the billets rolled, and in the economy of the labor employed. A personal visit was made to the Bradford iron works, to see the operation of this ingenious and successful machine. It appears to be all that could be desired, and the action of the rolls upon the iron unquestionably produces a sounder and better rod than when worked by the old process, and this is due doubtless to the higher and more uniform heat at which the rod is finished.[1]

In the use of wire for telegraphic purposes, for wire suspension bridges, and for cables and ropes, the superior value of long lengths is undeniable. Bedson's machine has therefore the double merit of producing a better article, at a lower cost, than has hitherto been obtained; and it is a matter of regret to those who have become familiar with its novelty and its merits, that it received only the recognition of a silver medal, when it so justly deserved the highest prize.

[1] The same principle has been since successfully applied to the rolling of bar iron.

Borsig, of Berlin, exhibited remarkable specimens of gigantic puddle balls, a single one weighing 1,064 kilograms, (more than a ton,) and he also exhibited a wrought-iron piston without a weld, weighing 590 kilograms, (nearly 12 hundred-weight.) These are not mere *tours de force*, as he is prepared to take orders at a price which renders it economical to employ his product.

In connection with the large masses of iron with which, as demonstrated in the Exposition, modern industry so much occupies itself, it is proper to refer to the crank shafts exhibited by Messrs. Marrel frères, of Gier, (France.) Of these one has three cranks placed 120° apart, and has a length of nearly 40 feet, the weight being 30,180 kilograms, or about 30 tons. Another is a four throw crank, say 27 feet in length and 12 inches in diameter.

Among the new applications of iron exhibited in the Exposition are the weldless bands made at the Bowling and Low Moor works,[1] (England,) employed for uniting the cylindrical sections of steam boilers, covering the joints and strongly riveted on each side thereof, so not merely as to make a firm union, but greatly to stiffen the boiler when finished. The Bowling ring has a cross section like the letter U, with wide flanges, and seems better adapted to stiffen the boiler or flue, and to allow of expansion and contraction, than the flat ring made by the Low Moor works.

The one on exhibition is seven inches in total width, three-eighths thick, the arch in the middle rises two inches, and the width of the flanges is two and one-half inches. These bands would appear to be thoroughly well adapted to their purpose, and worthy of immediate adoption in our country.

CAST STEEL.

In cast steel, by whatsoever process produced, the same tending to large masses and difficult shapes was to be remarked. In advance of all other makers, the specimens exhibited by Krupp, of Essen, (Prussia,) were worthy of the highest admiration. The largest single piece of cast stell was a cylindrical ingot forged at one end into an octagonal shape, 56 inches in diameter, and weighing 40 tons. The grain of this ingot was exposed by the fracture of the forged end, and was uncommonly uniform and free from air bubbles. A piece had also been cut from the portion not forged, which showed at the place of fracture an equally uniform grain.

At the English exhibition of 1851, a cast steel ingot exhibited by Krupp, weighing two and a quarter tons, caused more astonishment than the ingot we have just described, because the world has since become familiar with metallic masses of enormous size, but the progress made in sixteen years in the production of cast steel is none the less marvellous, especially if considered in connection with the machinery necessary to produce and

[1] For a description of the process of making iron at Low Moor, Bowling, and Farnley, the reader is referred to "Percy's Metallurgy of Iron and Steel," page 732.

work the ponderous ingots into shape, and the organization of the labor and skill required for their formation.

The establishment of Krupp occupies about 450 acres, of which one-fourth are under roof. The number of men employed in the works is 8,000, besides which 2,000 more are employed in the coal mines, at the blast furnaces, and at the ore mines. The production of these works in 1866 was 61,000 tons, more than the entire production of cast steel in the world at the time of the first English exhibition. The value of this product was over $10,000,000 in currency. It was accomplished by means of 412 smelting, reverberatory, and cementing furnaces, 195 steam engines, ranging from 2 to 1,000 horse-power, 49 steam hammers, in the largest of which the hammer block weighs 50 tons,[1] 110 smiths' forges, 318 lathes, 111 planing machines, 61 cutting and shaping machines, 75 grinding machines, 26 special tools. 1,000 tons of coal are consumed daily in the manufacture of steel alone, and 120 steam boilers are in use evaporating 150,000 cubic feet of water daily. Fifteen miles of rail are laid in the works alone, and 6 locomotives and 150 cars are required for its use within the limits of the establishment.

In order to appreciate the eminent justice with which the grand prize of the Exposition was bestowed upon Frederick Krupp, it is not merely necessary to study these marvellous figures, but to consider that this establishment, by far the most extensive ever produced by the energy of man, and these processes, the most difficult ever attempted by his ingenuity, are the offspring of a single life, begun almost by the side of his father's humble forge, and rising through the various stages of poverty, trial, discouragement, and final success, to the very front of the industrial achievements of the world. Such an establishment, such results, and such a man, have special interest for the United States, where the natural resources of the country, the rapid progress of population and civilization, and the genius of our free institutions, all invite a generous emulation in order to equal, and in course of time even to surpass these magnificent achievements, which, if Krupp, the great captain of modern industry, had not lived in our day and generation, might well have been deemed impossible.

Among the other remarkable specimens exhibited by Krupp is a cast steel tire, rolled without weld, eight feet in diameter, a cast steel axle of crucible steel, with cast steel disk wheels, neither forged nor rolled, but cast directly into shape, weighing 1,623 pounds; a cast steel locomotive crank axle, with cast steel wheels six feet in diameter, weighing 3 tons 13 hundred weight; a cast steel junction ring of angular section, for uniting the courses of steam boilers, made without weld, eight feet in diameter, weighing 483 pounds; a cast steel double crank shaft for a screw steamer, 25 feet long, 14 inches in diameter, weighing (finished) 9¼ tons; forged under the 50-ton hammer from an ingot originally weighing 27 tons. And this is a proper place to note that cast steel crank shafts appear to

[1] Krupp is now erecting a hammer of 120 tons.

be coming into general use, not merely for locomotive and stationary engines, but for the massive marine engines which are required for the steamers devoted to the business of transatlantic navigation. The experience with these cast steel crank shafts for marine engines does not appear to be sufficiently extensive to warrant any positive opinion as to the comparative value of cast steel and iron for the purpose, and it is possible that in cases where great resistance to torsion is required, iron will maintain its place. In any event the attention of engineers has been so called to this subject by the Exposition, that we may expect soon to have all doubts on this important subject removed.

The most striking object, however, in Krupp's exhibition, was the cast-steel 1000-pounder rifled breech-loading gun, resting on a cast-steel carriage intended for the arming of coast batteries for the destruction of iron-plated ships. It consists of an inner tube, upon which are shrunk cast-steel rings. This tube was forged under the 50-ton hammer, from an ingot weighing 40¼ tons, but reduced in the process of manufacture to 20 tons by the loss of the sinking head, and by forging, turning, and boring. The cast-steel rings are three in number at the powder chamber, and two in number towards the muzzle portion of the gun. These rings weigh 30 tons in the aggregate, and were each manufactured from an ingot without welding. The total weight of the gun is 50 tons, the diameter of the bore is 14 inches, and the total length of the gun is 210 inches. In has 40 rifle grooves, in depth .15 inch, and the twist of the rifling diminishes from one turn in 980 inches to one turn in 1,014.4 inches; the weight of the solid shot is 1,212 pounds, and of the shell 1,080 pounds, and the weight of the latter is made up of the cast-steel shell, 834 pounds, the lead jacket, 220 pounds, and the bursting charge, 17 pounds; the charge of powder for the gun is from 110 to 130 pounds. The cannon reposes upon a steel carriage weighing 15 tons, and the two together work upon a turn-table weighing 25 tons. The turn-table was not exhibited for want of space, but it was stated that the gun-carriage slides smoothly upon the turn-table to the cheeks at the backstays at each discharge of the gun, and that two men can quickly and easily elevate, depress, and turn the gun so as to follow and cover with speed and certainty any vessel in motion. The price of the gun, which is understood to have been made for the Russian government, is £15,750 sterling, and of the carriage and turn-table £6,000, being about $150,000 in currency. Sixteen months of unremitted labor, by day and night, were expended upon its manufacture, and its transportation from the works to the Exposition required a car made entirely of steel and iron, weighing 24 tons, resting on 12 wheels.

It forms no part of the purpose of this report to institute a comparison between different systems of ordnance, or even to undertake to decide the relative value of cast and wrought iron and steel for the manufacture of guns, but it has been deemed best to give a somewhat elaborate description of this monster engine of war, in order to indicate the possibilities of construction in its most difficult and expensive form, in case experience should show that such weapons will hereafter be required in our own country. In this connection a comparison with the largest guns produced in England will be of interest. Sir William Armstrong exhibits a 12½-ton 9-inch muzzle-loading rifled gun, constructed on the coil principle, and mounted on a wrought-iron carriage and slide; the weight of the projectile is 250 pounds, and the charge of powder 43 pounds. This gun is beautifully made, and is noteworthy from the fact that the compression for checking the recoil is wholly of iron, and is thrown in and out of action by a lever-handle, which is self-acting if neglected. The gun is designed for use on shipboard. The largest Whitworth gun exhibited is a 150-pounder, and is constructed exclusively of mild steel, wrought into tubes, which are forced into each other by hydraulic pressure. But to us the most interesting gun is the 9-inch Paliser gun, made by casting an exterior coating of iron around an interior barrel of wrought iron, constructed on the coil principle. This gun carries a projectile of 250 pounds, and if in practice it should be found to have substantial advantages over our cast-iron guns, it suggests a method by which we may apply the principle to the reconstruction of the large number of cast-iron guns which have been accumulated during the last few years. The gun now manufactured by the British war department, at Woolwich, consists of a cast-steel tube, upon which rings of fibrous wrought iron, made upon the coil principle, are built up, and the specimen exhibited was a 12-inch muzzle-loader, weighing 470 hundred-weight, length of bore 145 inches, having 9 grooves, each 1½ inch wide and .2 inch in depth, the spiral increasing from one turn in 1,200 to one turn in 600. The weight of the charge of powder is 70 pounds, and of the projectile 600 pounds.

The only other gun requiring notice was a cast-steel gun, made by Petin, Gaudet & Co., weighing sixteen tons, and intended to throw a projectile of 300 pounds in weight; but it was quite evident that the manufacture of steel and wrought-iron guns in France is still in its infancy, and there would seem to be the same uncertainty in regard to their value as prevails in the United States. But there would seem to be no doubt that within certain limits of size, and perhaps for all sizes of field-pieces, cast steel is regarded as the best material, and Krupp has already produced more than 3,500 cast-steel guns, mostly rifled breech-loaders, and at the present time has orders in hand for immediate delivery of 2,200 guns, ranging from 4-pounders to 300-pounders. Not much accurate information is to be procured in regard to the endurance of the larger sized guns, but Krupp exhibited a cast-steel rifled 4-pounder breech-loading gun, belonging to the Prussian war department, which had been fired several hundred times, with gradually increasing charges up to three and three-quarters pounds of powder and 122 pounds of shot, without the slightest appearance of injury.

Although no evidence was afforded by the Exposition of the substitution of cast-steel for cast-iron shot in the French service, my visits to the French iron works seemed to show conclusively that such is the case, as all the large establishments were actively engaged in the manufacture of cast-steel missiles of all sizes, but more especially of the larger calibre; and whatever the fact may be, it is quite evident that cast steel is regarded by French military engineers as superior to all other materials where penetration is required.

Krupp also exhibited a cast-steel rail 50 feet in length, and bent double, cold, in the middle, without fracture. His engineer in the Exposition stated that their annual product of rails was about 30,000 tons, and that no Bessemer steel was employed in their construction. In the absence of a personal visit to the works, we are bound to accept this statement as true, although it is stated on good authority that as many as nine pairs of converters are constantly employed at the works in the production of Bessemer steel, and there seems to be an impression that the tires latterly produced at Essen are not quite equal in quality to the remarkable material which was at first employed for this purpose. This may be only the result of rival representations, and it is undeniable that up to the present time Krupp maintains his pre-eminence in the manufacture of locomotive tires, and is probably justified in the claim which he makes, that his crucible cast-steel coils are superior to those made from Bessemer metal. In the year 1865 the sale of cast-steel tires amounted to 11,396 sets, and the guarantee of their endurance given by Krupp is that they will run 400 kilometres for each kilogram of weight, (equivalent to 125 miles per pound;) that is to say, a tire weighing 600 pounds is guaranteed to run 75,000 miles, but their actual performance as a general rule shows a much higher endurance. The results with these tires and those of other makers—such as Naylor, Vickers & Co., Firth & Sons, the Bochum Company, Petin, Gaudet & Co., the Bowling Company, and the Monk Bridge Company, and other respectable makers, would seem to justify the broad statement that the day for iron locomotive tires has passed by, and that it is far more economical, if not more safe, to substitute cast-steel tires in every case.

The same conclusion cannot yet be affirmed of rails, because the interest account, of but little consequence in the case of the tire, becomes a very serious and indeed controlling element in the case of rails. It may be stated, however, that in all cases where iron rails wear out in consequence of hard service within the limits of duration assigned to a steel tire, it is quite as economical to use steel rails in lieu of iron ones as it is to use steel in lieu of iron tires. But, assuming the cost of cast-steel rails to be double that of good iron rails, it is quite evident that there must be a limit in the duration of iron rails beyond which it will not pay to substitute cast steel. This calculation is one which must be made by each consumer for himself, with reference to the available capital at his disposal; but it is safe to declare that on all roads where the iron rail has an average life of ten years it would not be profitable to substitute cast-steel rails, and so long as the average rate of interest paid by railroad companies in the United States amounts to eight per cent. per annum it would be found expedient considerably to reduce the limit of ten years above assumed for the duration of iron rails before the substitution of steel rails could be justified on grounds of economy. Even in England, where capital is superabundant and the rate of interest on long obligations not over five per cent., and the traffic per mile of very large dimensions, requiring, as a general rule, the renewal of iron rails in seven years, cast-steel rails have thus far not been very extensively introduced; and even on the London and Northwestern railway, which owns a mill devoted expressly to their manufacture from Bessemer steel, and which, from its enormous traffic, has every inducement to make its road as permanent as possible, the money question seems to check the use of cast-steel rails upon any very extended scale. And yet the necessity of more durable rails than those generally in use is so apparent that any attempt to secure greater durability without much additional cost is regarded with great interest, and hence in the Exposition there were many specimens, and from all the leading nations, of *iron* rails with *steel* heads. In some cases the material employed for the head was puddled steel, in others cast steel, and in others Bessemer steel. It seemed to be generally admitted that the durability of the steel in the head was in nowise impaired by its being placed upon a cushion or bed of wrought iron, but the great difficulty appeared to be in securing a thorough union or weld between the two kinds of metal. In the Austrian department, where some admirable specimens of steel-headed rails were exhibited, from the Neuburg Works, the engineer in charge stated that nine per cent. of the heads failed in the weld during the first year, but that subsequently no failures occurred, and that even with this amount of loss the rails were regarded as cheaper than either steel or iron. At Crewe, where the works of the London and Northwestern Company are situated, and where a considerable quantity of Bessemer steel-headed rails have been made, it was stated that some difficulty had been found at first in making a reliable weld of the steel to the wrought iron, and that as many as five per cent. of the rails first made had failed in consequence of the loosening of the steel top; but as experience was acquired in the manufacture this difficulty had disappeared, and the percentage of loss had been reduced materially. The practice at Crewe is to place a bar of soft puddled iron between the steel of the top and the old rails used in the lower part of the rail, and as a further protection the steel for the head is rolled in the form of a channel bar, with ribs in the recessed portion so as to fold around and embrace, as it were, the head of the rail. Considerable experience has already been acquired in the United States as to the feasibility of making a sufficiently good junction between the iron and steel for a durable rail, and it may be confidently affirmed that there is no practical difficulty in the way of making an iron rail with a steel head, whether of puddled, Bessemer or cast metal, that will meet all the reasonable requirements of the case, and reduce the failures to less than one per cent. The cost of steel-headed rails is, of course, intermediate between that of all iron and that of all steel rails, and the system possesses the great advantage of rendering all the old rails available for re-manufacture, and of thus renewing the tracks with a bearing surface of steel by gradual steps, and with a very moderate increase of cost. On the London and Northwestern railway, which has had the most experience in the use of Bessemer and steel-headed rails, experience seems to show that the steel-headed rails possess all the requirements in point of cost and durability for their general introduction on the line, and the conclusion is irresistible in my own mind, after a careful study of the specimens in the Exposition, that the steel-headed rail will ultimately prevail over all other kinds of rails now known, and that in the United States the facilities for their manufacture are unusually favorable. It is a question in what manner the steel shall be made for the heads, and this point will be discussed when we come to speak of processes, and it is enough to state here that a good steel head can be made from any one of the kinds of steel above specified.[1]

In closing this brief statement of the remarkable specimens of cast steel in the Exposition, the products of the Bochum Company (Prussia) should not be overlooked. An enormous cast-steel bell, weighing 29,500 pounds, remarkable for the admirable proportion which existed between its size and its tone, was not, however, more wonderful than the cast-steel railway wheels made in sets of ten or a dozen, united by a thin shaft of metal running through the centres, thus enabling one sinking head to answer for the whole quantity, and securing greater density and soundness in the metal. These wheels, when cut apart and turned up, were beautifully sound and clean, and gave evidence of ability to cast steel with as much facility as ordinary cast iron. Another evidence of this was to be found in a locomotive cylinder, bored and of such finish and soundness as not merely to excite general admiration, but induced the belief that possibly it was cast iron which had been deprived of its carbon by being annealed in a bath of oxide of iron, or some other decarbonizing material.

In the Swiss department, machine-cut steel files were exhibited fully equal to any cut by hand; and this result is said to be due to the grinding of the blanks across the face instead of lengthwise, a point which may have great value to our own makers of files.

QUALITY OF MATERIAL.

A careful observer of the iron and steel specimens in the Exposition could not fail to be struck with the varieties in the quality of the metal exhibited and the evident attention paid to the adaptation of special

[1] In view of the great interest which this country has in securing good rails, I have obtained permission to insert in an appendix (F) a very valuable paper, recently read before the British Association of Civil Engineers, by C. P. Sandberg, esq., inspector of railway material for the Swedish government.

qualities to special uses. In some establishments only a particular quality would be produced, but, as a general rule, all the large works exhibited, and seemed prepared to produce, a quality proportioned to the price to be paid.

In the pavillion of Le Creusot, for example, seven different qualities of merchant iron were displayed as examples of the uses to which each quality would be applied, and a personal visit to the works satisfied me that there was nothing fanciful in these grades. In the Welsh iron works it is notorious that the quality of the article produced is directly proportioned to the price paid for it, and in my visits to those gigantic establishments which have grown up in the mountains of South Wales, it was humiliating to find that the vilest trash which could be dignified by the name of iron went universally by the name of the American rail.

This is no fault of the Welsh iron-master, but has arisen from the almost universal practice of late years, on the part of American railroad companies and contractors, of purchasing the lowest-priced article that could be produced. Of course no iron of this quality was to be found in the exposition; but if prizes were to be given for mere human ingenuity, I cannot conceive of anything more entitled to it than the production of a well-finished rail from puddled balls, that will not hold together under the alligator squeezer.

There is, however, one thing more remarkable even than this low quality of iron; and that is, the stupidity and reckless extravagance of the customers who are found to buy it. To this cause, more than any other, is due the necessity of almost annual renewals of rails in the United States, and of the financial troubles of so many of our leading lines of railway; nor is there the slightest excuse for this result, for the Welsh iron-masters, to their credit be it said, make no concealment either of the inferiority of the material, or the poverty of the process by which it is treated, and greatly prefer to turn out work creditable to themselves, and profitable to their customers. But the inexorable law of competition, and the unremitted cry for cheap iron in America, have left them no choice.

For their own country, for the continent of Europe, and for India, no such system is practiced. As a general rule, all rails made for home consumption are guaranteed for from five to seven years, according to the traffic; that is to say, every rail that fails in the slightest degree within the time specified is renewed at the expense of the maker. The extra price paid for a guaranteed rail on roads of moderate traffic is about 30 per cent., but on roads having a heavy traffic at least 50 per cent. additional is paid. In cases where the guarantee cannot be procured in consequence of the heavy usage to which the line, or any portion of it, is subjected, the conclusion is inevitable that a steel rail should be used. And until a similar system of guarantee and adequate payment therefor is introduced into the United States, shareholders in railway companies can place no reliance on the security of their investment and the permanency of dividends.

It is this difference in the quality of iron, and its corresponding money value, which enables particular works and special regions to thrive under local disadvantages as to cost. To some extent the same rule applies in the United States, but it may be affirmed that there is no civilized country in which the discrimination is made to so small an extent, and which loses so much by its indifference.

A very remarkable proof of the adoption of particular quantities to particular purposes is to be found in Sweden, which possesses inexhaustible stores of primitive ores, many of them adapted to the manufacture of steel and the very highest grades of bar iron, and yet, for some purposes, ores which contain phosphorus are absolutely preferred to the purer ores, even through procurable at the same price. For tools, such as spades, shovels, hoes, and other utensils, and for roofing-sheets, which are to be subjected to severe wear, at least one-tenth of one per cent. of phosphorus in the iron is considered desirable.

Again, in France, in order to produce the better grades of iron, ores are brought in large quantities from Elba and Algiers, at a high cost, which is reimbursed by the purchaser.

If there was any lesson clearly taught in the Exposition, it was the willingness of the public to pay an adequate price for skill and quality, and this willingness must spring from an enlightened self-interest.

There is no difficulty whatever in producing in the United States any quality of iron and steel that may be desired, for we have an exhaustless profusion of the best kind of ore and coal, and, at the present day, so open to communication as to render them available with as little expenditure of human labor as in the most favored countries of Europe. But the problem presented for solution to the American iron-master has not merely been to procure this labor at as low a cost as it is obtained in Europe, (a requirement utterly impossible to be met,) but to produce the highest grade of material in competition with the price of the poorest foreign article. For the difference in the price of labor a remedy may be found in the tariff, but for the other exaction there is no remedy but greater intelligence on the part of the consumers, and in all cases where life or limb is at risk, the enforcement of the law as to the responsibility for the use of inferior material.

PROCESSES OF MANUFACTURE.

Having completed a brief survey of the articles in the Exposition which to the eye of an American would appear remarkable, we come next to the consideration of the processes employed in the manufacture of iron and steel which have not yet been introduced, to any considerable extent, in the United States. And first, in the natural order, comes the production of wrought iron and steel by a direct process from the ore. To some extent this branch of industry still continues in the United States, especially in the northern part of the States of New York and New Jersey, where the process employed is usually but incorrectly known as the Catalan method of making wrought iron. But in Europe this mode of making iron may be said to have died out, although in the mountains of Spain, and some portions of Italy, a few fires still maintain a feeble existence. The practial mind of Europe and America, however, has never ceased its efforts to produce wrought iron and steel directly from the ore, by some convenient and economical process, and perhaps at no time has this subject received more attention than at the present. Of this interest, however, the Exposition afforded but a single example, but that example in a quarter so distinguished both for scientific and mechanical knowledge, and for success so eminent in another direction as to have merited the grand prize of the Exposition, that it seems reasonable to expect the solution of this difficult problem, if it be at all possible, at the hands of Charles William Siemens, whose regenerating furnace will be the subject of subsequent consideration. In the exhibition of Mr. Siemens were some small specimens of cast steel, which had been made direct from the ore, but which would scarcely have been remarked but for the eminence of the maker. They were made in conformity to a patent issued to Mr. Siemens on the 20th September, 1866, in which he states that his invention has for its object the production of iron or steel directly from the ore, and in a continuous manner, analogous in this respect to the continuous action of the blast furnace; and consists in exposing a mass of ore, which may or may not be mixed with reducing agents or fluxes, upon an inclined surface, to the surface action of intense heat, and in introducing at the same time a current or currents of combustible gases or petroleum oil in among the mass from below the inclined surface, so as to percolate through the mass of ore, affecting or aiding in its reduction, and at the same time enveloping its surface where exposed to the flame in a deoxidizing or reducing atmosphere, tending to facilitate its fusion. The fused metal and cinders accumulating at the foot of the inclined surface are from time to time removed, while a mass of ore is maintained upon the inclined plane by its own gravitation, fresh ore being supplied from hoppers at the top of the incline in regular quantities. The intense heat spoken of in this description as necessary for the process is produced by Siemens' regenerative gas furnaces. Mr. Siemens has been conducting experiments upon the red hematite ores at Barrow in Furness, with a view to demonstrate the practicability and economy of this process, but it is yet premature to estimate the measure of his success. If, however, he should succeed in practice, with the magnetic ores of the Atlantic highland range stretching from New York to Georgia, and the primitive peroxides extending from the great lakes through Missouri and Arkansas, with the command of the fuel and the petroleum indispensable for its success, this process will be of incalculable value to the United States.

In the preparation of ore for the blast furnace, Sweden exhibits the model of a roasting furnace invented by Mr. E. Westman, and which was adopted in the first place at Dannemora works, and since generally introduced at the other iron works in Sweden. It consists of a vertical furnace which is heated by a portion of the gas drawn from the blast furnaces themselves, and introduced at the bottom of the roasting furnace through suitable flues by the aid of natural draught. The temperature in the furnace is carried to such a degree as to soften the ore, and drive off the sulphuric acid arising from the oxidation of a portion of the sulphur, disengaged by a distillation of a lower temperature from the pyrites, which may be mixed with the ore; a portion, moreover, of the sulphur is oxidized by the oxygen of the ore. Ore thus roasted, however dense when charged into the roasting furnace, is discharged at the bottom quite porous, like a sponge, and almost entirely free from sulphur, if it do not contain more than four per cent. in its natural state. With ore so roasted, and which presents an entirely different appearance from ore prepared in a common kiln, the statement is not surprising that the blast furnace runs with far greater regularity and with much less consumption of fuel. The introduction of this roasting furnace will be of great value when magnetic ores are smelted with charcoal. It is highly probable that even in furnaces fed by mineral coal, it will bring into economic use a great variety of ore now rejected on account of sulphur. So important did this furnace appear, that the undersigned at once engaged a Swedish engineer to proceed to America, where he is now erecting a furnace at Ringwood, in New Jersey, so that at an early date it may be examined by the public.

Besides economizing coal, the Westman furnace, in connection with other improvements resulting from a more accurate knowledge of the theory of the blast furnace, and a careful study of its operation, has greatly increased the weekly product of the charcoal furnaces in Sweden. The general dimensions of the blast furnaces are from eight to nine feet across the boshes, and from forty to fifty feet in height. The average product of these furnaces driven with a blast heated to 150° to 200° Centigrade is about seventy-five tons per week, which is nearly double the product made a few years since, and now made in the United States from the same class of magnetic ores, which must be carefully distinguished from the brown hematites of Connecticut and the peroxides of Lake Superior. The charging of the furnace, in particular, is most carefully attended to; absolute uniformity in the size of the pieces of ore is insisted upon, and the charge is distributed over the furnace by a shovel, in which it is first weighed. and then run on a suspended railway to the tunnel head of the furnace, which is never closed. The most intelligent engineers expressed the opinion that the furnaces would give better results if made larger; but as they are, 100 pounds of cast iron are produced with ninety pounds of charcoal, which is as near as possible at the rate of 112 bushels to the ton. To supply this quanity of coal it is estimated that 5,000 square metres (about 6,000 square yards) of wood land are required, and the most vigorous care is practiced in order to insure a perpetual supply of wood to the works. This is not in consequence of any regulation of the government, as is generally supposed, but by a concurrence of action among the Swedish iron-masters, who have an association administered with great vigor and intelligence. For the production of 100 pounds of bar iron from the pig 100 pounds of charcoal are required where the works are upon a scale sufficiently large to work to the best advantage.

The English run-out or refinery fire is not in use in Sweden, but the refining is all accomplished in the ordinary forge fire generally in use in Pennsylvania. Various modes of treatment in this fire are employed, but the one most generally used is the Lancashire method, substantially the same as the Welsh process generally employed in the United States. At Dannemora the Walloon method is employed, and at Elfsborg the method of Franche Comté is in use. At Kihlafors a combination of the Walloon and Lancashire methods is adopted, which is said to produce a very superior quality of iron with a very small consumption of coal. A detailed description of these methods may be found in Percy's Treatise on the Metallurgy of Iron and Steel, pp. 591, 604. They all give good iron if they are properly followed.

The special interest which these Swedish irons have for us consists in the fact that at this day, as for many years past, they are regarded as indispensable for the production of the best quality of cast steel by the crucible process. Hence the exhibition made by Sweden was among the most interesting in the Exposition, and it is creditable to that country and its iron-masters that it was not only most complete in all its details, but afforded an opportunity of studying its peculiar process of manufacture, from the ore to its final result in the highest grade of cast steel. The Swedish exhibition was in charge of a most intelligent engineer, Mr. L. Rinman, who took the greatest possible pains to furnish whatever information might be desired in regard to the manufacture of metals in Sweden.

The Dannemora irons have generally a fine grain, but unequal in size, composed apparently of hard and soft particles, but in ductility and tenacity the strength of this iron still maintains its superiority over all others; and it has the remarkable peculiarity that, when heated, it becomes very soft and full of fibre, and when cemented and cast into steel the inequalities of fracture entirely disappear. The irons made by the Lancashire fires are generally the most equal in grain, and this is supposed to be due not so much to the primary process of manufacture as to the peculiar mode of reheating and hammering to which they are subsequently subjected. For reheating, the gas welding furnace, as it is called, is usually employed, by which the bloom is subjected to so high a heat as to become incandescent, so that when subjected to the hammer all raw iron breaks in pieces, and is thrown off in the forms of small bits and blue sparks. Loops which act in this way are absolutely rejected for commercial purposes, and are only used for the local wants of the works themselves. There can be no doubt in my mind that to the use of the gas welding furnace, and the high heat, coupled with care in the selection of ores, is due the superiority which must be accorded to

Swedish over American iron made by the charcoal process. For steel, iron ore containing phosphorus is absolutely rejected, and it is a curious fact that Mr. Le Play, so long ago as 1846, prepared a table of Swedish iron, arranging their rank according to the price which they bore in the steel market of Sheffield, and the subsequent analysis of these irons shows that this value, determined by the practical experience of the manufacturers of steel, is directly determined by the quantity of phosphorus and sulphur contained in the pig iron from which the bars are made.

Inasmuch as the consumption of Swedish iron in the United States is very considerable, and the demand for that quality of metal is likely to increase, to be met either by importation or by domestic production, I have deemed it best to append to this report a copy of the table obligingly furnished by Mr. Rinman, giving the names and marks and kind of ore used in all the Swedish iron works; and also to append an analysis of the different kinds of pig iron from which they are made. A careful study of these two tables (Appendix A) will not only guide the consumer in the selection of the kind of iron which he may require for special purposes, but will enable the American iron-master to select the kinds of ore with which he may hope to replace Swedish iron in our own markets. But let it not be supposed that this last result can be achieved by ore alone. The same care in the manufacture, and the same severe test which is applied to the loops, heated to the highest point, will be required to insure a uniform and satisfactory result. The best form of gas furnance is probably that of G. Ekman, models of which were exhibited in the Exposition, and a description of which can be found in Percy's Metallurgy, page 716.

It is well to note that in the forge, or sinking fires, two tuyeres are generally employed, placed opposite to each other, by which the production is increased and the consumption of coal diminished, and the iron is generally regarded as more homogeneous. Puddling with wood is also practiced to a considerable extent in Sweden; and, in this connection, although somewhat out its proper order, it is best to describe the furnace devised by F. Lundin, of Carlstadt Munkfors, designed for the consumption of turf and peat, without drying, and of wet sawdust or other moist fuel; an invention deemed so valuable that the association of Swedish iron-masters have rewarded Lundin by a gift of $10,000, which, in Sweden, is a very considerable sum. In this furnace the fuel is fed by a hopper into a reservoir, resting upon an inclined grate, supplied from below with air from a blower. The products of combustion thus produced pass through a condenser, where all the moisture in the gas is condensed. The gas then passes to the heating furnace, which is furnished with Siemens' regenerators. It is found easy to use fuel containing as much as forty-five per cent. of water, and the resulting gas contains about thirty-three pounds of water to one hundred pounds of dry gas, and the water, after condensation, contains about two per cent of its weight in gas, or three per cent. of its volume. The condensing apparatus consists of 3,500 pounds of iron bars piled crosswise on each other, and kept cold by a jet of water from a tuyere. The heat of the gas before condensation of the water always melts lead easily, and sometimes zinc. The expense of the construction of a full-sized furnace in Sweden is about $2,500 in currency, and it is estimated that such a furnace will utilize 1,700 tons of fuel in a year, at a saving proportioned to the cost of other fuel in the particular locality where it is employed. In Sweden it is estimated that the annual saving, resulting not merely from the cost of the fuel, but from the repairs of the furnace and the increased temperature, amounts to over $5,000 per annum on the product of each furnace.. In the Ekman furnace dry wood containing eight per cent. of water produces in the generators gas of a temperature of 1,394°, while in the Lundin furnace the temperature is 2,666°, the combustion in both cases being produced by cold air. The gas produced by seasoned wood contains more water than that which proceeds from the Lundin condenser. The duration of the furnace is simply surprising, and is to be attributed probably to the fact that there is no cinder. In eight weeks the thickness of the roof, 4 inches, was only diminished from ¼ to ⅜ inch, and the side walls were entirely uninjured. So wonderful is the success of this system of condensation, in connection with the Siemens' regenerators, that, in Sweden, and in fact everywhere where moist fuel is employed, the Lundin furnace will supersede every other. Its great merit is, that it is available for any kind of fuel whatever. In the United States it is believed that this arrangement might be employed advantageously for washing the gas obtained from mineral coal; but its chief merit consists in the fact that in mineral regions, far removed from the coal fields, it is possible to establish iron works, using sawdust or peat with entire success and great economy. In the lumber regions of Lake Superior it will be found to have a special value, because there is an abundant supply of pig accessible to the saw-mills on Green Bay and in Michigan, producing enormous quantities of sawdust, slabs, and waste timber.

Although reluctantly I have been compelled to abandon the idea of accompanying this report with drawings, and to rely rather on references to printed publications, the drawings of the Lundin furnance are annexed in Appendix B, not merely because they are not elsewhere attainable, but because the value of the invention is such as to secure its immediate introduction into the United States, in many parts of the country where mineral coal is dear or not attainable.

The Exposition presented very complete specimens of pig iron from all parts of Europe, but the experience valuable to our American iron-masters could only be acquired by actual visits to the works where they were produced. In South Wales the most remarkable feature was the endurance of the furnaces, some of which had been in blast for more than 20 years, and no furnaces were expected to go out of blast under 10 or 12 years. As the production of these furnaces varies from 200 to 300 tons per week, and the ores and coal are not less calculated to wear the lining than our own, it would be very desirable to determine the cause of this greater durability. In Wales the heat of the blast is usually about 600°, and its pressure from three to three and a half pounds per square inch. As all these conditions are to be found at particular works in the United States, where furnaces continue in blast only from three to four years, it would seem that the quality of the bricks might explain the difference. Another peculiarity of South Wales is the great difference in the product of furnaces having the same dimensions and shape and using the same materials, and for which the experience of the iron-masters offered no adequate explanation. Again, at Ebbw Vale, the Sirhowy furnace, 73 feet in height, 18 feet across the boshes, with the hearth seven feet six inches in diameter, and the tunnel head ten feet in diameter, containing 11,900 cubic feet, did not produce as much iron as another furnace seventeen feet six inches across the boshes, forty-eight feet high, with the same sized hearth and top containing 6,590 cubic feet. This latter furnace averaged about 380 tons of iron per week, using about one and a half ton of raw coal to the ton of iron. Its interior section was in the form of two cones meeting at the boshes, and a drawing of it will be found among the Ebbw Vale furnaces, marked E. V., No. 3, p. 559 of Percy's Metallurgy of Iron and Steel. The only mechanical arrangement of these furnaces worthy of special notice is the cup and cone device at the tunnel head, which is described in Percy, page 470, perfected at the Ebbw Vale iron works, and now generally adopted at all the large iron works in Great Britain and on the continent, except in Scotland and in the Cumberland region, where it is supposed to have an unfavorable influence on the quality of the iron. The object of this arrangement is to throw the small ore and coal against the sides of the furnace, and the large pieces to the centre, and it was stated to be essential that the cone when drawn up to its place should have a space of 18 inches between it and the lining of the furnace. From the space thus produced the gas is drawn off for the supply of the hot blast ovens and the boilers, which, in the great majority of cases, were placed upon the ground and not upon piers, and no difficulty is experienced in procuring an adequate supply of gas below by the draught of high chimneys. It was generally stated that the adoption of the cup and cone arrangement had improved the running of the furnaces and diminished the consumption of coal.

The Cumberland region has long been remarkable for the large product of iron from its blast furnaces. Even as early as 1862 a weekly product of over 600 tons had been achieved in one furnace, and although the business has greatly extended in that region, and is still characterized by larger weekly products, it does not appear that any improvements have been lately made either in construction or in yield. At Barrow-in-Furness there are six furnaces 15 feet across the boshes, by 42 feet high; and five furnaces of 17½ feet across the boshes, and 47½ feet high. When working for pig iron designed for the Bessemer process, the smaller furnaces make 300 and the larger 400 tons per week of extra gray pig iron, but this product is very largely increased when the furnaces are running on forge iron, a single furnace having made as much as 700 tons in a week. This remarkable product is due to the admirable character of the ore, which is a red hematite, yielding 60 per cent. on the average, and is smelted with a ton of coke per ton of iron, but when the grayest iron is made the consumption of fuel is undoubtedly greater. Admirable as these works are in construction, and producing annually the enormous quantity of 200,000 tons, there was nothing in the process of manufacture calling for special notice.

But at no point in Europe was the lesson of the superior advantage of good quality more plainly inculcated, for here, on the west coast of England, gray hematite iron was selling for 90 shillings a ton, while on the east coast of England gray Cleveland iron could be purchased for 40 shillings per ton; the one finding a market in the Bessemer process, where only the very best iron can be used, while the other had to be sold in competition with the great mass of inferior pig. But though the iron of the Cleveland region be inferior, it is there that the American iron-master has most to learn. The ore of the Cleveland region is of the fossiliferous variety, yielding 31 per cent. raw, and 42 to 43 per cent. when roasted. The coke is extremely tenacious, enduring a heavy pressure without being crushed. The first furnaces built were about 18 feet in diameter and 55 feet high, making a weekly product of about 230 tons, with a consumption of 1½ ton of coke to the ton of iron, and a temperature of blast of from 600° to 700°. The excellent performance of the stock in the furnace soon led to an increase in its height, with a corresponding increase in the temperature of the blast, and now there are furnaces in operation in the Cleveland district 102 feet in height, 27 feet across the boshes, and driven with a blast of a temperature of from 1,000° to 1,100°, or at least sufficient to melt pure zinc, back of the tuyeres, in from four to five seconds. The consequence is that the consumption of fuel has been reduced to a ton of coke to the ton of iron, and there has been a gain of two per cent. in the yield of the ore, which latter phenomenon is attributed to the use of the Player stoves for heating the blast. In this arrangement the gas is burned in a separate chamber, and only the resulting heat reaches the pipes. Thus all floculent matter is disposed of and the pipes require no cleaning, and their liability to injury is far less than when the flames come in contact with the pipes, subjecting them to the danger of being burned in spots. The pressure of blast is from 3½ to 4½ pounds to the inch, and six tuyeres of 3½ inches diameter usually serve to convey it to the furnace. At the Norton works, where there is a furnace 85 feet high by 25 feet boshes, there were four stoves, containing 60 pipes weighing 126 tons, which heated the blast from a blowing cylinder of 7 feet by 7 feet, making 13 revolutions per minute. The general rule for blast is that there shall be 1,200 square feet of heating surface for each 1,000 cubic feet per minute.

The effect of this change in the size of the furnace and the heat of the blast in the Norton furnace above referred to was to give a weekly product of 365 tons. All these furnaces have the cup and cone arrangement at the tunnel-head, and the gas is drawn off into a great iron flue forming a kind of cornice or moulding around the top of the furnace, but covered with brick so as to avoid radiation. A proper outlet for the gas is indispensable for the larger product and economical results which have been described. The pipe for conducting the gas to the ground must not be less than 7 feet in diameter, and is lined on the inside with brick.

All the ore of the Cleveland region is calcined in vertical kilns, varying from 24 to 35 feet in height, and from 4,500 to 8,000 cubic feet capacity, charged with ore and fine coal in layers, and consuming about one ton of coal to 24 tons of ore. This calcining might be far better done by the Westman furnace, but unhappily the supply of gas from the blast furnace is not more than sufficient to heat the boiler and stoves. All the usual modes of elevating material to the top of the furnace are to be found in this region, but the pneumatic lift more recently introduced merits attention, as working in a very satisfactory manner. It consists of a cast-iron cylinder of the height of the furnace, made in sections bored out and bolted together, so as to provide a chamber 36 inches in diameter, in which the piston fits loosely, and weighs about half a ton more than the platform and empty barrows. Leather packing is used to render it air-tight. The platform surrounds the cylinder, and is put in motion by the movement of the piston, with which it is connected by wire ropes passing over four eight-foot pulleys at the top of the cylinders. Four barrows of material are raised at a time, weighing from one to two tons, and the upward and downward motion is communicated by the alternate exhaustion and compression of air beneath the piston to the amount of from one to three pounds per square inch, according to the load. A pressure of one pound to the square inch is required to lower the empty barrows. For the calcining kilns, a similar arrangement, but of greater power, is employed.

The early introduction of the high furnaces into the United States would seem to be inevitable, provided the fuel is strong enough to resist the pressure which is involved. Our magnetic, carbonaceous, fossiliferous, and red hematite ores, except in a few instances, are remarkably well adapted to these furnaces, and if it should be found that our admirable anthracite will not decrepitate when subjected to the incidental pressure, it is not hazarding much to predict that the consumption of fuel can be readily reduced to a ton for each ton of iron made.

An analysis of the coke used is subjoined, as a guide to those who employ that fuel:

Carbon	91.4[illegible]
Volatile hydro-carbons	0.6[illegible]

Sulphur	1.
Ash	6.66
Moisture	0.28

Among the other curiosities connected with the Cleveland iron, is an analysis of the dust which is deposited by the gas in its passage from the furnace through the stoves and under the boilers.

Protoxide of iron	14.22
Oxide of zinc	10.48
Sulphide of zinc	13.70
Alumina	8.20
Lime	12.32
Magnesia	5.03
Chloride of silicon	4.74
Ammonia	0.70
Thalium	trace.
Sulphuric acid	3.18
Free sulphur	0.17
Silica	22.60
Carbonaceous matter	4.50
Total	99.84

So large a proportion of zinc from an ore which contains no zinc is a phenomenon not unobserved at other places, but has as yet received no satisfactory explanation.

The Player stove was the subject of commendation in the Cleveland region, and appeared to be as satisfactory a mode of heating the blast as any in use. But it is proper to say that an equally high temperature can be procured in other ways.[1] The introduction of a hotter blast into the United States will certainly effect a large saving of fuel, but the effect upon the quality of the iron must in a great measure depend upon the character of the ores employed. Its combination, however, with the high furnaces certainly affords one of the most interesting and instructive lessons in recent metallurgic improvements.

In Scotland, where for so long a time the yield of blast furnaces was in advance of all other regions, no progress seems to have been made, the furnaces rarely exceeding 200 tons per week. An attempt has indeed been made at Gartsherrie to increase this amount by the erection of two furnaces 60 feet in height, but the consumption of fuel has not been reduced, and the yield of the furnace in iron not materially increased.

This is noted here in order to suggest caution in our own progress toward higher furnaces, because the increase in the height of the furnace at Gartsherrie appears to have increased the quantity of solid matter

[1] Stoves made with fire-brick, under Cowper's patent, or modifications thereof, are found to work well, and are growing in favor. They are described in Bauerman's admirable "Manual of Metallurgy" republished by Van Nostrand in New York.

which falls down into the hearth and very much adds to the labor of working the furnace. It has been suggested that a modification in the shape of the furnace might relieve this difficulty, and some new furnaces erected by Mr. D. Adamson, in North Lincolnshire, are cited as an example of the advantages of bringing down the lines of the furnace almost parallel to a very low point, and then drawing them in quickly towards the hearth. But in the absence of a larger experience it would be unsafe to recommend any other course but extreme caution in departing from successful practice.

Passing from blast furnaces to rolling mills, the most striking change presented in the new works is the simplicity of the machinery, its large dimensions, and their arrangements for dispensing with labor in the handling of the material. Reversing mills are generally employed in Great Britain in preference to three-high rolls, but in France it is to be noted that at Anzin, in Isère, three-high trains have been in use for rolling girders since June, 1849. There is also a three-high plate mill at Le Creusot, and the principle of three-high mills appears to be perfectly well understood in Europe, but the reversing mill is generally preferred. Direct acting engines—that is, engines without intermediate gearing, are generally preferred, but at Crewe, in the plate mill the fly wheel was dispensed with; a pair of engines similar to a locomotive engine were used, running at a high speed and geared down so as to give the proper number of revolutions to the train. At Ebbw Vale there is an engine, driving a small train, (running 250 revolutions per minute.) In both these cases the result was entirely satisfactory to the managers. Another striking feature in the rolling mills and in some of the larger steel works was the adoption of the hydraulic crane for moving the masses of metal, and where the hydraulic crane was not used the steam crane often supplied its place. The ratio between human labor, and the quantity of material handled, has thus been greatly reduced, and apparently brought to a minimum, and in the United States, where labor is so dear, the introduction of hydraulic machinery as a substitute for human muscles is an imperative necessity.

The arrangements necessary for this purpose are not complicated, although somewhat expensive. Where an adequate pressure of water, say 300 pounds to the square inch, can be procured, from an adjacent height, as at the admirable works of Naylor, Vickers & Co., in Sheffield, the expense is lessened, but in other places it is only necessary to erect an accumulator and supply the pressure by artificial means; and even the accumulator may be dispensed with by the use of the duplex steam pumps generally employed in America. The steel-rail mill of John Brown & Co., at Sheffield, and the new steel works of Naylor, Vickers & Co., at Sheffield, are admirable examples of the perfection to which this hydraulic system has been carried; and taken as a whole I regard the latter establishment as the best specimen of mechanical engineering which has come under my observation.

Attention should also be directed to a tool for slotting the ends of rails, so that they may be all of exact length, which is indispensable in order to secure a perfect railway joint. The cost of this operation is about two pence per rail, and the machine is not expensive. Another machine for cutting rails cold, at John Brown & Co's., was worthy of observation. It was a circular saw 16 inches in diameter and ¼ of an inch thick, making 20 revolutions per minute and cutting 6 steel rails per hour. Another feature admirable for the order and cleanliness of the mill was the cemetery for rolls not in use, which were all buried in special tombs prepared for their reception under the iron floor of the mill, whence they were easily removed by cranes.

Among the names of those who give dignity to the grand prize of the Exposition stands that of Charles William Siemens for his gas regenerative heating furnace; and although this invention has been long enough in use thus to command the homage of the scientific world, it is only within a few months that it has been introduced for the first time into an iron works in the United States. Its practical success is, however, undeniable, and for the reheating of steel, whether made by the crucible or the Bessemer process, or for the heating of iron, where a clean incandescent heat is required, or for any of those operations in which wrought iron is required to be kept in a melted condition, its necessity is unquestionable. Its merits, however, are not limited by these results, for which it was originally designed, but enable hitherto useless or nearly worthless forms of fuel to be employed with entire success. At Crewe, where coal alone is used for reheating, five hundred weight suffices to do the work of a ton under the old plan, and at the time of my visit they were using half saw-dust, saving thereby one-fifth of the coal, that is to say, two and a half hundred weight of saw-dust was found to be equal to one hundred weight of coal. At the wire works of Richard Johnson & Nephew, as we have already seen, the consumption of coal was reduced from about fifteen hundred weight to eight hundred weight per ton of billets heated, and the waste from 10½ per cent. to 6.9 per cent. At Bolton the manager assured me that the results were equally satisfactory, although he considered it an open question whether, in cases where the waste heat was used for making steam, there would be much economy of fuel by the use of the Siemens' furnace, but he had no doubt whatever as to the saving in waste and the increase of product from the furnaces. Aside from the question of the quality of the iron produced, the Siemens' furnace in the United States will be found of most value where coal is dear, and, above all, at works driven by water power and the surplus heat now allowed to go to waste. The application of the Siemens' furnace to puddling is quite recent. I saw it in operation at Le Creusot, in France, and at Bolton, in England. At the former place the coal, which is an impure kind of anthracite, had required some modifications to be made in the generator, so that the advantages could not be estimated, but at Bolton the furnace worked so much more rapidly than the old furnace that it was necessary to put on three shifts of hands per day, and no difficulty of any kind was found in the operation of the furnace. I regard it, therefore, as one of the most important improvements to be introduced into American iron works at the earliest possible day.

The success of Siemens has given rise to many attempts to improve the ordinary puddling furnace, and at Bolton I found in operation the Wilson furnace, which differs from the common furnace in having the coal fed in from a hopper over the fuel chamber on to an inclined grate, and with a bridge which causes all the smoke to be consumed before reaching the stack. Although this furnace has been tried previously at other places and abandoned, yet at Bolton it appears to be working well. The consumption of coal was less than a ton to the ton of iron, the number of heats in twelve hours was increased from six to seven, and the waste of the iron was stated to be decidedly less. In case subsequent experience should confirm the promise of the experiment as I saw it, it would seem that in works where the waste heat is required for raising steam, the Wilson furnace could be introduced with more advantage than the Siemens' furnace for puddling.

In the Exposition among the articles exhibited by the Dowlais works was a puddle ball of unusual dimensions, made in the mechanical puddling machine constructed by Mr. William Menelaus, the able and experienced manager of this extensive establishment. A visit to the works proved that no expense had been spared in order to substitute puddling by machinery for the work by hand. A building and engine had been put up expressly for the purpose, and four massive machines erected, capable each of heating a quantity of iron sufficient to produce a ball of six hundred-weight. The puddling vessel is of a shape that would be produced by revolving the bottom of a puddling furnace, and is caused to turn on a horizontal axis resting on firm bearings. The vessel is first charged with iron, either cold or melted, and then lifted by a steam crane and placed on its proper bearings, and as soon as the metal is melted, thrown into gear and caused to revolve. It was expected that the puddling operation would be accomplished by the simple revolution of this vessel, supplied with the products of combustion from a furnace placed at one end. When the heat was completed, the vessel was lifted from its bearings by the crane, the bridge end turned down, and the ball dropped out upon a carriage ready to be taken to the hammer. There were of course many other details, which it is unnecessary here to describe, as the results achieved were not such as to encourage imitation. The first difficulty was found in procuring a lining material which would withstand the chemical action of the metal and cinder, and the mechanical action of the iron from the time it came to nature until it was balled up. Ganister was tried and failed, because the iron produced was invariably cold-short. Titanic ore from Norway was found to stand nearly as well as the ganister, and the iron produced was less cold-short, but with neither could a satisfactory iron be produced. Iron linings failed, because the iron under treatment adhered to the sides of the vessels; and Mr. Menelaus makes this important statement, that it is next to impossible to prevent puddled iron from adhering to the *clean* surface of an iron lining heated to the temperature necessary for puddling. It was also found that artificial blast was necessary, but notwithstanding over 600 tons of iron were made in these vessels, and the highest order of mechanical talent brought to bear upon the process, neither the lining could be made to stand nor the iron brought up to a merchantable quality.

The problem of mechanical puddling, therefore, still remains unsolved, but the manual labor of the puddler can undoubtedly be considerably diminished by the use of puddling tools or rabbles, moved backwards and forwards around the furnace by a series of levers put in motion by steam or other power. At the Northfield iron works, near Sheffield, such machinery, invented by John Griffiths, was in operation on a single double puddling furnace, in which ten hundred-weight of pig was charged and six heats were made daily by one puddler and two boys helping him. It was claimed that 2,400 pounds of puddled iron was being produced with sixteen and a half hundred-weight of coal, and there certainly was a saving of one skilled workman. And yet it was stated that where these machines had been put into the works, and left to the option of the puddler to be used or not, and the same price per ton paid for the result, the puddlers had declined to use them. But whether because they were really found to be of no service, or because they feared their use would bring down the rate of wages, it is impossible to say.

So far as my judgment goes, I think they could be introduced with great advantage to both masters and men.

At Le Creusot, in puddling white pig iron for rails, they make eleven heats per turn, or two and a half tons, in a furnace with one puddler and two helpers, which is a larger yield than I have any knowledge of elsewhere, but it is certainly not due to any peculiarity in the furnace.

Player, the inventor of the hot-air stove, has also taken out a patent for what he terms a blooming process, by which the entire heat is removed from the puddling furnace in one mass, and carried to the hammer on a suitable carriage, thus saving the expense of separating the heat into small balls. Trials are now being made with this process, but it is yet too early to give any positive opinion as to the result.

Of the value of another improvement, however, made by John Beard, there can be no doubt. This invention consists in placing the grate-bars of the puddling furnace upon two axles, at the front and back of the fire chamber. To these axles a vibrating or rocking motion is given by means of levers, the effect of which is to raise the grate-bars alternately at opposite ends, so that each grate-bar vibrates up and down in an opposite direction to its adjacent grate-bar. The value of this improvement consists in the facility with which the grates are cleaned and freed from all clinker without breaking up the fire. It was already introduced into the Blaenavon works, in South Wales, and those of John Brown

& Co., at Sheffield, where it was stated to give an additional heat from the furnace per turn, and to make a considerable saving in coal.

The manufacture of puddled wire-rods is a very extensive business in Great Britain, but no one has succeeded in naturalizing it upon American soil. With the best grades of charcoal iron it is indeed possible to make good puddled wire rods in the United States, but at a cost too high to compete with the foreign article, in the production of which no charcoal is employed. I visited the works of J. C. Hill & Co., near Newport, in South Wales, and those of Richard Johnson & Nephew, at Manchester. In both these works, a mixture of several brands of coke iron is employed, costing on the average about £4 per ton. Single puddling furnaces alone are used; the charge of iron is 4½ cwt., and the yield from 3¼ to 3½ cwt., made up into five balls, and showing a waste much larger than usual. These balls are hammered under a five-ton helve, to a bloom four inches square, and this bloom is taken hot to a balling furnace, where it is heated and rolled down to the ordinary 1⅛-inch billet for wire. The greatest possible care is taken at all stages of the operation, but the result of my observation is, that the puddling furnance is the stage in which the iron receives its proper preparation for a wire rod, and I think I may say that as a general rule, when high grades of iron are to be produced, I remarked a higher standard for the puddled bar than I have been accustomed to see in the United States. The practice of puddling for grain instead of fibre is more general, and I think I cannot be mistaken in saying that the puddle balls are far more thoroughly cleaned of cinder when puddled for grain. At Blaenavon and at Le Creusot, at which works very superior iron is made, the grain of the puddled iron resembled puddled steel more than iron, and it seems probable that we shall hardly attain to the same regularity of product in America until the same careful attention is paid to the puddling process.

The propriety of rerolling old rails seems to be involved in as much doubt in England as in the United States.[1] The general practice, however, is to sell the old rails and purchase new ones, but at Crewe the London and Northwestern Railroad Company, and at Swindon the Great Western Railroad Company have mills for reworking their old rails. There was a concurrence of opinion in both establishments that new iron should be used in the head, and at both the steel-headed rail with old rails in the base was looked upon with favor. At Swindon I saw a beautiful steel-headed rail which had been made by balling up cast-steel turnings in a common balling furnace and placing the resulting bar on top of a rail pile. The fracture was admirable and the weld appeared to be perfect. There seemed also to be a general agreement that the top slab of a rail pile should not be less than one and a half inch in thickness, and two inches is preferred. At Blaenavon puddled steel is used for heads with very satisfactory results, but care is taken that the layer of steel on the finished rail shall not be less than five-eighths inch thick.

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[1] See Appendix F.

PROCESSES FOR THE MANUFACTURE OF STEEL.

By common consent it seems to be agreed that the most striking feature of the industry of the present day is the marked advance in the manufacture of steel and its progressive substitution for iron, in all cases where strength must be combined with lightness. Notice has already been taken of the enormous masses of steel in the Exposition, but it was only by observing the infinite variety of forms and purposes to which it was applied, that the intelligent observer was compelled to admit the transition which is taking place from the age of iron to the age of steel. Another conclusion could not fail to be reached from a careful study of the products and processes represented in the Exposition, viz: that good steel can only be made from good material, no matter what process is employed. For the best steel the crucible process still maintains the first rank, and although the Exposition contains some beautiful specimens of material made by other processes, yet it was quite evident that no plan has yet been made sufficiently practical to infringe upon the domain of crucible steel for the more difficult and higher uses for which this metal is required. The process of making crucible steel is too well known at this day to require description at my hands, but like all other branches of the metal business it has of late undergone an immense extension in the size of the works and of the products.

At the establishment of Thomas Firth & Sons, in Sheffield, the old system of making steel is maintained in its integrity, and of a quality unsurpassed by any other maker. And yet here I saw a 12-ton ingot cast for the tube of a Woolwich gun, poured from crucibles containing each about 50 pounds. In order to make a solid ingot it is indispensable that the metal should be poured continuously into the mould at a high temperature, inasmuch as any delay in discharging the crucibles would be fatal to the quality. The difficulty of preparing this quantity of metal in such small instalments so as to reach the mould in due season, and of organizing the gangs of men necessary for its transfer, will easily be appreciated by those who are familiar with the magnitude of the task. The only evidence in these works, besides the masses of steel, of the new era upon which the business has entered, was to be found in the enormous steam hammers, furnaces, and cranes, which had been rendered necessary in order to fabricate ingots of such massive character. So admirable were these arrangements that there seemed to be no greater difficulty in dealing with these heavy masses of steel than with the smallest ingot on the premises. Here the fabrication of cast-steel locomotive tires has just been undertaken, with every possible facility for its successful operation. A cylindrical ingot is first made sufficiently large for six or eight tires; this ingot is then cut in a lathe into sections, each of the shape of a cheese, sufficiently large for a single tire. The steel cheeses thus produced are heated and thoroughly hammered under an immense steam hammer, and, after being reduced in all directions by this process, are again heated and punched with a conical-pointed punch under another steam hammer. The ring thus produced is enlarged by successive heatings and hammerings until it reaches the size suitable for the tire rolling-mill, where, after being again heated, it is rapidly finished, producing a ring without weld or joint.

Inasmuch as the relative value of tires made by the crucible process and the Bessemer process is still a subject of discussion, I took special pains to compare the toughness of the crucible steel, as shown in the clippings of the fin on the finished tire, with the same clippings from the Bessemer tires, and no doubt was left in my mind as to the superiority of the crucible material; but I do not wish to be understood as saying that the Bessemer material is not good enough for the purpose, and, in view of the relative price, more economical in use, Firth's tires being sold at £45 per ton and the Bessemer as low as £28. The mode of making crucible tires at the works of Naylor, Vickers & Co., was somewhat different, and appeared to be less expensive; and here one could not fail to be struck with the admirable adaptation of mechanical means to the objects in view, and with the very complete arrangements for the production of large masses of crucible steel. Here again was presented the perpetually recurring question as to the relative value of Bessemer steel for special purposes, such as crank shafts and locomotive crank axles, which are produced at these works in large quantities and from crucible steel. Of the value of the latter no doubt seems to be entertained, and the makers of the former insist that their work is equally reliable at a far less cost; but I must again acknowledge that I saw no Bessemer steel in England of equal toughness with the product of the best makers of crucible steel. In the Exposition, on the other hand, there were specimens of Bessemer steel from Sweden and from Austria which appeared to be fully equal in quality to any crucible steel, and these may be the precursors of the coming day when crucible steel will be a thing of the past, but that day has not yet arrived.

The past year may be said also to have decided the substitution of cast steel for iron in guns of small calibres. The peculiar excellence of the Marshall iron is still admitted, but it cannot be denied that cast steel is freer from "grays" or specks, and, in point of tenacity, quite as reliable. When steel is employed for this purpose the barrel is not welded, but is generally bored after being forged to the proper length.

The Chassepot rifles are all being made in this way, but another method, known as that of Deakin & Johnson, is being introduced, with considerable probability of its general adoption. In this process the ingots, after being hammered to about five inches in diameter, are cut into pieces of suitable weight for a gun barrel, and punched in the same manner as has been described for the punching of tires. The blanks so punched are heated and hammered, and then rolled over a mandril into a cylindrical tube about a foot in length, which is again heated and rolled over a mandril into a gun barrel. This process forms the subject of a patent, although it is difficult to find anything in the process which is novel, except, possibly, in its limitation to gun barrels. It is applicable, however, either to cast steel or to Bessemer steel, the latter being generally employed.

The Bessemer process is, of course, the great feature of our day in this department; and in order that it might be treated in such detail as its importance demands, it was deemed by the committee best to make it the subject of a special report, and this duty was confided to Mr. Fred. J. Slade, an American mechanical engineer, who had already devoted several months to its careful study, in the interest of the American patentee. His report is hereto annexed, and will be found fully to justify the confidence of the committee in intrusting him with this important duty. I have verified the accuracy of his statements by extended personal examination, and it is only necessary for me to add one or two general conclusions at which I have arrived. The first is that the Bessemer process will not, as Mr. Bessemer originally supposed, supersede the puddling process, which appears to be, as yet, the only method applicable to the conversion of by far the larger portion of the pig iron made into wrought iron; because by far the larger portion of the pig iron made is of a quality not good enough for the Bessemer process, which, in the absence of sulphur and phosphorus, is absolutely exacting. It is true that an antidote may yet be found for these two poisons, in which case the area of the Bessemer process would be enormously extended. But even then there would be a limitation to its general use (and this is my second conclusion) arising from the uncertainty as to the quality of each particular cast, requiring a special test for each in every case where it is to be subjected to great strains. But, even when this precaution is taken, it is found that in the manufacture of tires and of gun barrels there is a very considerable percentage of failure from undiscovered flaws, which show themselves in the cracking of the ingot when subjected to the severe test of the steam punch. Hence, in my judgment, it is not safe to use Bessemer metal in any case involving the security of life or limb, unless, in the process of manufacture, it has been subjected to such tests as will certainly show all its defects.

I think it is safe to use it for tires and for gun barrels that have been made by the punching process, but I should think it unwise to employ it for solid railway axles made in the ordinary way. If punched and made hollow, this objection would not apply, and doubtless it would not be difficult to devise a method of making a solid axle from Bessemer steel that would be free from objection.

In view of the small amount of Bessemer steel as yet produced in the United States, we are struck in Europe with surprise at the enormous provision made for its supply; and it is quite evident that the business is overdone, and, contrary to all past experience, the inventor and the public at large seem to have profited by its introduction at the expense of the manufacturer.

As an adjunct to the Bessemer process, the Parry process must be mentioned, having for its object the conversion, in a cupola furnace, of wrought iron which had been freed from phosphorus and sulphur by the puddling process into pig iron adapted for the Bessemer process. For this method of operation extensive works were erected at Ebbw Vale, but they have been abandoned, and the patent has been purchased by Mr. Bessemer.

This process would have very considerable value if the metal could be tapped from the cupola in the form of steel instead of pig iron, but this does not appear to have been practicable, inasmuch as the product was a white pig iron, containing two per cent. of carbon. A charge of 22 hundred-weight was worked at a time, and required from 55 to 75 minutes for its treatment, which involved a waste of twelve per cent. It might possibly be used advantageously for the conversion of the ends of Bessemer rails into pig, in case they should ever become so cheap as to warrant the operation. It might also be used for melting down the metallic sponge, which can be made by cementation from our rich ores in America, but certainly without advantage in point of cost, unless the product should have qualities attainable in no other way. The production of steel from the cupola furnace is still a desideratum to be attained, but among the possibilities of the future.

A careful study of the Exposition showed but two other processes for making steel worthy of notice, and both French: the one patented by A. Berard and tried at the forges of Montataire; the other that of Emile and Pierre E. Martin, in operation at Sireuil. In both these systems cast steel is made in a reverberatory furnace. In Berard's process the conversion of the pig iron into steel is sought to be achieved by subjecting the melted metal alternately to a decarbonizing and recarbonizing flame, for which purpose it is necessary to employ blast. He uses a Siemens' furnace, and avails himself of the changes of current required in working the regenerators to affect the changes of flame. The furnace is divided by a bridge into two halves, and he thus operates upon two masses of iron at the same time, one of which is freshly charged, while the other contains material which is nearly decarbonized. Some specimens of Berard's steel were on exhibition, and although creditable in themselves, it was generally understood that he had not yet succeeded in making steel regularly for market. The Messrs. Martin, on the contrary, were not only making steel regularly at their own works at Sireuil, but the process is also in operation at two of the largest works of France—Le Creusot and Firminy—and is in process of erection at various other works in Europe, and arrangements have been made for its immediate introduction into the United States. In this process the pig iron is deprived of its carbon by the addition of pieces of wrought iron or steel either in the form of shingled puddle balls, or of scrap. The quantity, however, of wrought iron necessary to reduce the carbon to the required limits, is much less than would be inferred from the consideration of the quantity contained in the pig, and does not in practice much exceed the quantity of pig itself. A charge of gray pig or of spiegeleisen is melted in a Siemens' furnace, having a bed hollowed out to contain it, and is allowed to remain about half an hour after fusion to bring it to an intense white heat; portions of malleable iron previously brought to a bright red heat are then added in successive charges of about 200 pounds, at intervals of twenty minutes to half an hour, each charge being thoroughly melted before the next is added. After two or three such additions, ebullition commences in the bath of metal, and continues till the carbon is wholly removed from the pig. The exact condition of the metal is ascertained from small proofs taken from the charge, after each addition of iron towards the end of the operation. These are run into a small ingot mould, and when cooled to the proper heat, hammered into a plate, about $\frac{5}{16}$ of an inch thick by 5 inches in diameter. When the decarbonization is completely effected these proofs will bend double cold, and show a fracture quite fibrous. A quantity of pig, generally of the same kind as was used for the preliminary charge, is then added in such proportion to the amount of iron in the furnace as to give the desired hardness to the steel, according to the use for which it is required. When this is melted the bath is well stirred to insure homogeneity in its substance, and a final proof taken, which is treated in the same manner as the others, and gives reliable evidence as to the state of the metal before pouring. This enables the quality to be very exactly adjusted to the degree of hardness required. Should it be too soft, more pig is added, while if it is too hard, the mere waiting from a quarter to half an hour will materially soften the metal. Arguing from this fact, Messrs. Martin claim that under the influence of such a high temperature, the carbon is to some extent spontaneously disassociated from the iron, and attribute in a measure to this the fact that so small a proportion of wrought iron is required to effect the decarbonization of the pig. The coating of scale formed on the iron in the preliminary reheating which it undergoes before being charged into the furnace, also assists in the removal of the carbon. When the metal has been brought to the desired condition, it is tapped off at the rear of the furnace into ingot moulds placed on a railway car, and thus brought successively under the gutter.

A considerable number of specimens of steel made by this process were exhibited, ranging in hardness from a metal too hard to be touched by a tool to a true wrought iron, intended to be used in the manufacture of armor plates. At Messrs. Martin's works, at Sireuil, the process has been in regular operation during the past two years for the manufacture of gun-barrels, and some remarkable specimens of these were exhibited. Thus there was one that had been tested with very large charges of powder and a heavy weight of shot, which, by very palpable bulging just behind the balls, testified as to the softness and toughness of the metal. In another, which had been burst by a similarly severe charge, the metal had merely torn open for a certain length of the barrel, and the lips so formed were simply folded back 180″, without any sign of cracking. There were also shown specimens of tool-steel, of excellent fracture, castings of pieces of machinery, such as gears and framing, and a large tube for a cannon of extremely soft metal, or melted iron, as it is named.

The hardest variety of metal, called by the patentee "mixed metal," is considered suitable for castings which do not require to be worked by tools, but where great strength is required, such as hammer blocks and anvils, large gears, &c. By a subsequent process of annealing or discarbonization, carried on in a gas furnace, under the influence of an oxidizing flame, these castings may be softened so as to be quite malleable and easily worked, and they then retain the advantage of being free from blow-holes. This metal is produced by adding to a preliminary bath of say 1,600 pounds of pig 2,400 of wrought iron, and adding at the end 1,200 pounds of pig. For tool-steel, to a bath of 1,600 pounds of gray pig would be added 2,600 pounds of puddled steel from the same pig, and at the end of the operation 400 to 500 pounds of spiegeleisen. For homogeneous metal, the preliminary bath at Sireuil is 1,200 pounds of spiegeleisen, to which 2,000 pounds of soft iron, puddled to grain, from the same pig, is added, and at the end of the process 200 to 300 pounds of the same pig is charged, to give the requisite amount of carbon. The softest metal of all, which, however, has not as yet been made an article of regular manufacture, is made in the same way, with the exception that the final charge of manganiferous pig is but 5 per cent. of the contents of the furnace. With certain kinds of gray charcoal pig this proportion rises, however, to 20 per cent., since under the influence of the high temperature they refine spontaneously with great rapidity.

Messrs. Martins' patents also cover the use of ore either with or in place of the wrought iron or steel used for removing the carbon from the pig, and when this is used the progress of the operation is much more rapid. It has the objection, however, that the slag formed attacks violently the bricks forming the sides of the furnace, and therefore requires frequent renewals.

This process has the great practical advantage that all the scrap arising in the manufacture of any product, such as the ends of bars, &c., is readily remitted to the furnace and immediately returned in the form of useful ignots.

The flame in the furnace is kept always slightly surcharged with gas, an effect which the use of the Siemens' furnace renders easy and certain, and by this means the waste of the metal is always moderate.

For the production of soft steel suitable for gun-barrels or for tires this metal already enjoys considerable reputation in Europe, and, indeed, were it not for its excellent quality, it would be impossible to sustain the manufacture at Sireuil, where there is neither iron nor coal, the latter being brought from England and the former from various parts of France.

The results here stated were verified by a personal residence of Mr. Slade during several weeks at the works at Sireuil, and the regular and commercial success of the process was in that way seen to be fully achieved.

It is not asserted that cast-steel can be made as cheaply by this process as by the Bessemer; but where a product of definite quality is to be produced day by day, without rejections to any considerable extent, the Martin process has a decided advantage over the Bessemer, and in comparison with the crucible steel is decidedly less expensive. Its chief drawback would seem to lie in the difficulty of keeping the furnace in order, and only the most refractory materials will withstand the high heat required for its operation. As much as five tons of steel have been produced by this process at a single heat, and there is no difficulty in combining the product of several furnaces where larger masses are desired, inasmuch as the temper of the heat in each furnace can be brought and maintained to exactly the same standard. It would seem also to present the best solution yet devised for the difficulty experienced by the accumulation of the ends of Bessemer steel rails, inasmuch as these can be used in lieu of the puddled iron required by the process. It is possible, also, to use old rails in the same manner, and, indeed, any old scrap, but the resulting quality of the steel will, to a great extent, depend upon the quality of the old iron so used.

A visit to the works of Messrs. F. F. Verdié & Co., at Firminy, showed, in confirmation of facts gathered from other sources, that the steel manufacture of France, instead of being in the advanced degree of perfection, often supposed in our country, has been but very moderately successful. These works were established for the manufacture of crucible steel and forgings on a rather large scale, but to-day the production of steel by this process has been entirely abandoned, and with the exception of some puddling, all the steel now made is by the Martin process, for which three furnaces are now in operation and others in course of erection. The same thing appears to be true at other works, and it is quite certain that no considerable amount of good cast steel is produced in France.

In order to enable a comparison to be instituted between a first-class Swedish iron and Bessemer steel, containing various degrees of carbon, I annex (Appendix D) the tabulated results of a series of experiments made by David Kirkaldy, at his well-known testing and experimenting works in London upon 11 bars of billet iron from the Degerfors iron works in Sweden, and 12 hammered bars of Fagersta Bessemer steel of various degrees of hardness, resulting from different percentages of carbon, which are indicated by the stamp on the bars; that is to say, 0.3 means three-tenths of one per cent. of carbon, 1.2 means one per cent. and two-tenths, and in like manner for intermediate stamps.

WORKS FOR THE PRODUCTION OF IRON AND STEEL.

The description of the large mass of steel and iron exhibited in the Exposition has led, incidentally, to an account of the magnitude of the iron works of Krupp. But this report would fail to give an adequate idea of the magnificent scale upon which the metallurgic industry of Europe is conducted at the present day, if reference should not be made to other establishments in other countries. In France the most extensive works are those of Le Creusot, near the centre of the empire, which is especially commended in the report of the jury of recompense for organizations which best develop a good understanding between masters and workmen, and secure the material, moral and intellectual welfare of the operatives.

In 1845 the product of Le Creusot was about 60,000 tons of coal and 4,000 tons of iron. At the present time the production is 250,000 tons of coal and 130,000 tons of cast iron and 110,000 tons of wrought-iron. The works cover an area of 300 acres, of which more than 50 acres are in buildings, in which mechanical operations are carried on. The coal is mined in the immediate vicinity, and the quantity of ore which the region now furnishes is stated to be 300,000 tons per annum, but my impression is that this includes a large quantity brought from Algiers and Elba. There are 15 blast furnaces of large dimensions, fed by 160 coke ovens, and using the blast of seven blowing machines of 1,350 horse power, and 10 other engines for other purposes. The forge contains 150 puddling furnaces, 85 heating furnaces, 41 separate trains of rolls, 30 hammers, 85 steam engines of 6,500 horse power in the aggregate. This mill is all under one uniform roof, made of iron, and is about 1,400 feet in length, and is altogether in appearance and construction the most complete rolling mill in existence. And it is a remarkable evidence of the intelligence and courage of Messrs. Schneider & Co., the proprietors, that within the last few years they have deliberately abandoned their old works and machinery, and erected an entirely new establishment, in order to avail themselves of all the modern improvements in machinery and process. The machine shops require engines of 700 horse power for their operation, and contain 26 hammers and 650 working tools. The total number of workmen employed is 9,950, being, by a remarkable coincidence, the precise number of horse power represented by the steam engines in the works; that is to say, each man employs a machine power of one horse in addition to his own labor, showing the wonderful extension of human power which in our day has been realized out of the steam engine. 45 miles of railway, 15 locomotives, and 500 cars are required for the local operation of the works, and the enormous quantity of 1,400,000 tons of traffic is annually moved at the central depot of Le Creusot. All parts of the works are in communication by telegraphic wire. The total value of the productions is now about $7,000,000 per annum in gold.

On the whole these works may be regarded as the best model offered by Europe for the study of the iron business as it is, and they are not only an honor to the proprietors, but one of the chief glories of France.

The works of Petin, Gaudet & Co., are distributed among several establishments, which in the aggregate employ 5,200 men and a steam power of 6,000 horses. The annual production is about 50,000 tons of iron and steel, of the value of $7,000,000 in gold.

There are several other establishments in France which approach very nearly to these large proportions, and considering the disadvantages in point of fuel and ore under which the business is carried on, as compared with Belgium and England, the present development of the iron industry of France, amounting to an annual product of 1,200,000 tons of pig iron and about 800,000 tons of wrought iron, is one of the most striking features of the industrial progress of France during the present century.

In Belgium the iron industry has made remarkably rapid strides, the production of pig iron having advanced from 134,563 tons, in 1845, to 449,875 tons, in 1864, and there are many establishments in Belgium organized on a scale comparable to the best works in other countries. That of Cockerill at Seraing, in which the government is directly interested, produces 50,000 tons of pig iron, 26,000 tons of bars, and 5,000 tons of steel annually, consuming 80,000 tons of coke and 146,000 tons of ore, and mining 260,000 tons of coal.

In Prussia, the works of Krupp have already been referred to, and there are many other extensive establishments organized upon the best principles of modern construction.

The Phœnix works near Ruhrort, for example, produced during the last year over 50,000 tons of pig iron, and 40,000 tons of wrought iron, with 11 blast furnaces and the corresponding number of puddling furnaces. The total production of iron ore in Prussia, for the year ending 1865, was over 1,700,000 tons, which represents a production of iron of about 770,000 tons.

In England there are many works approaching in capacity to Le Creusot, among which may be enumerated the Dowlais and Ebbw Vale in South Wales, those of Bolckow, Vaughan & Co., in the Cleveland region, and of the Barrow Hematite Iron and Steel Company at Barrow-in-Furness, and of John Brown & Co., at Sheffield. A production of 2,000 tons per week is achieved in each of these vast establishments. Large towns are required to house the workmen and their families; hundreds of miles of rails and thousands of cars are appropriated to their special use. The human mind is lost in wonder at the combination of material and intellectual elements required for the organization and conduct of such gigantic operations, and standing in the presence of tools which seem formed to shape the universe, and of an artificial power which, in the aggregate, is too vast for any other estimate than by comparison with the force which moves the earth in its orbit, the triumph of man over matter is realized to an extent making it possible to comprehend in some degree the omnipotence of Deity himself.

One striking consequence of the vast size which has been given to particular works is their general transfer from individual ownership to that of stock companies; and although this transfer is not considered favorable to the economy of manufacture, the saving produced by production on so large a scale would seem to counterbalance the advantages in point of cost which are connected with individual ownership. Nor is this feature of association of ownership peculiar to any one country, but may be said to be the general rule in all. In England, owing probably to the business being overdone, none of these companies can be said to have achieved a pecuniary success, and the shares of all of them are at a considerable discount. This fact, producing profound dissatisfaction on the part of the owners, coupled with the feeling of restlessness and discontent with their wages among the workmen, has paved the way for the consideration and discussion of the problem, whether in these large establishments the true relations between capital and labor have been established, and in what way they may be placed upon a sounder basis, avoiding the ever-recurring contention between masters and men, which culminates in strikes injurious alike to both classes. The question has already stepped beyond the limits of private discussion, and governmental commissions are now investigating both in France and in England the facts and the principles upon which the organization of labor rests at this day, the points in which there is a collision between it and capital, the wrongs, if any, upon either side; with a view to such legislation as may render the march of industry regular, and profitable to all concerned. In some establishments engaged in the mining of coal and other branches of industry, outside of the iron business, the system of co-operation, as it is termed, has been introduced, with manifest advantage. But in all these cases the business is a profitable one, and has never yet been subjected to the strain which will attack the system when it is forced to deal with losses instead of profits. The general plan adopted in these co-operative establishments, such as Crossley's great carpet factory in England, is to reserve to the capital a fixed rate of interest, as high in some cases as 15 per cent. per annum; next to pay to the workmen a fixed rate of wages, being usually those which were in force at the time of the introduction of co-operation into the works, and to divide the surplus, if any, between capital and labor, on such terms as may be agreed upon, but usually in proportion to the amount of each employed during the year. There is a wide difference of opinion as to the practicability of introducing this system into the iron business, and there is a fear that it would not stand the trial to which it would be subjected in the long periods of depression to which the iron trade has hitherto been invariably subjected, and from which the co-operative system would not relieve it, because there would still be the same competition between the several co-operative associations, and the several nations, as now exists. Under the present system the capital is the first to lose its profits, and then comes the reduction in the wages of labor. Under the new system the reduction would fall first upon labor or in strict equity there would be the same percentage of reduction upon the earnings of capital and labor. It is feared that the laborer would not look with content upon any reward to capital under such circumstances, and that the old warfare between the two would thus be renewed.

On the other hand, it is believed that by the obvious harmony thus established between the interests of capital and labor, the latter would be led to see that the co-operation of the former is indispensable for the payment of wages at all, and that any attack upon capital or any diminution of its quantity would be a direct attack upon labor, by depriving it of the fund out of which it is paid, and that the conservation of capital would thus become so apparent as the highest interest of the laboring class that strikes would cease, and even in bad times, from the steady employment thus insured, the labor would be better paid than under the present intermittent system. It is urged, moreover, that the personal interest thus excited in the workman would lead to greater economy in the manufacture, and bring down all waste to the minimum, and that it would be possible to establish such intelligent relations among the owners and workmen of the several co-operative establishments, that over-production would be checked by common consent, in time to prevent the serious losses to which it now subjects the industry of the world. It is quite certain that this latter end is achieved in an imperfect degree even in present practice. In Scotland the number of furnaces in blast during the present year has been very considerably reduced, with a corresponding reduction in the enormous stock of iron which had weighed down the prices below the cost of production. In France, by a resolution of the Ironmasters' Association, a reduction of six per cent. was inaugurated in the early part of the present year, and there is a general recognition of the necessity and wisdom of this course in times of overproduction among the iron-masters of Europe. And it is impossible to see that there would be less discretion exercised, or a less prompt remedy applied, if the workmen had such a direct relation to the business as to enable them to feel that it would be better to work less days at the old rate of wages, than more days at a reduced rate, producing precisely the same pecuniary result.

No intelligent observer can fail to remark the universal cry which comes up from the laboring classes in all parts of Europe for the reorganization of the relations of capital and labor. In England it has shown itself in strikes long continued and in all branches of business, reducing the workmen to beggary, and destroying the profits of capital to such an extent that, in a spirit of self-preservation, it takes flight where it can from the walks of industry, and remains unemployed rather than incur the risks and the anxiety of its uses in active business. In France, where, as will be hereafter seen, the organization of a strike is full of difficulties, the same longing manifests itself, not merely in the organization of minor co-operative associations for the supply of the necessaries of life, the erection of houses, and the production of goods, but in a literature which seeks to analyze the social phases of industrial life and develop some better system for its reorganization. In the course of this almost microscopic examination of the social relations, property has been pronounced to be robbery, communism has been advocated as the remedy for all the social evils, and the autonomy of the individual lost sight of in the attempt to promote the welfare of mankind.

In Germany, on the other hand, under the practical guidance of Schultze Delitch, there have been established, up to the year 1865, 180 associations, with about 10,000 members, for the supply at wholesale prices of the raw material required by the members of the association in their several trades. These associations consist principally of shoemakers, carpenters, and tailors, and their business amounts to about 2,000,000 thalers[1] annually. There were fifty "magazine" unions, comprising about 1,000 members, and doing a business of about 500,000 thalers annually, having for their object the sale of goods produced by the members of the association in a common store. There were also 26 co-operative associations for the production and sale of finished wares on common account, some of which appear to have been successful, while others have failed to realize the expectation of the members; and as this is the only feature of the Schultze Delitch system which has not proved successful, it is well to note that all the associations were organized independently of any existing business or capital employed in its conduct. They proceed upon the basis of disassociation from capital, as such, in the management of the business, and although the founder still expects to achieve successful results with associations formed on this basis, it would seem to be too wide a departure from the experience of mankind in all times to dispense with the watchfulness and patient scrutiny with which capital guards itself from destruction. Of co-operative stores there were, in 1865, 157. These are said to have been of slow growth at first, but are now rapidly extending. But the great success of Schultze Delitch has been in the organization of his credit and loan associations, of which, in 1865, there were 1,300 in existence, with more than 300,000 members. These "credit banks," as they are commonly called, are formed by the workmen themselves, who are supposed to be without any capital of their own. The capital of the bank is procured by the subscriptions of the members, payable in instalments, and by loans contracted on the credit of the association. Of course the share capital can only be slowly accumulated, but experience has shown that loans made to the association are quite safe, because each member is absolutely liable for all the debts, and the funds of the bank are only loaned to its own members, within limits restricted by the nature of the business to be carried on by the borrower, and after a rigid scrutiny of his character. The cardinal rule in the conduct of these banks is to take the minimum of risk and the maximum of responsibility. This report is not the proper place to enter into the history and details of management in these credit banks, but in

[1] Each about 75 cents in gold.

order to show the progress of the co-operative movement in Europe, I append a brief statement of the business of 498 of these banks, whose statistics happen to be accessible. These banks had 169,595 members, and the total amount of money advanced to them during the year 1865 was 67,569,903 thalers, or, in round numbers, $50,000,000 in gold. The total income of these banks, mostly, of course, in interest paid by borrowers, was 1,401,896 thalers, of which 699,558 thalers was paid for interest by the banks on money which they had borrowed, and 316,403 thalers was absorbed by the expenses of management. The total losses were 20,566 thalers, and the net profits were 371,735 thalers. The share capital accumulated by these banks amounted to 4,442,879 thalers, the borrowed capital amounted to 11,154,579 thalers, and the savings deposits of the members amounted to 6,502,179 thalers, and a reserve fund of 409,679 thalers had been accumulated to meet losses. When it is remembered that these banks were started by workmen without any capital, and it is observed that the accumulations of capital, deposits, and reserve funds exceed 11,000,000 thalers, or $8,000,000 in gold, the beneficent operation of the principle upon which they are founded will be appreciated, and some conception may be formed of the wonderful economy which will be introduced into the industry of the world when it becomes the interest of each man not only to produce the best possible result from his own labor, but to see that his fellow-workman does the same thing. In such a reorganization of industry the eye of the owner will be literally everywhere, and the loss either of time or of material will become almost impossible. This topic of co-operation is introduced here because in the Exposition there were constant evidences not merely of its importance, but of its becoming the leading social question of our day and generation. A special prize was constituted in favor "of persons, establishments, or localities which, by an organization of special institutions, have developed a spirit of good feeling between those who co-operate together in the same labors and have secured the material, moral, and intellectual welfare of the workmen." Although Schultze Delitch was not an exhibitor, and no application for this prize was made on his behalf, and the special jury who had this order of recompense in charge lost the great opportunity of making themselves illustrious by voluntarily recognizing the greatest benefactor of the human race in our day, the labors of Schultze Delitch and the success which has attended his system, based as it is upon a profound knowledge of human nature, and the laws of social science, will survive the memory of the Exposition, and erect this monument in the reorganized structure of modern society.

In the United States, strange to say, we lack the legislation, either national or State, which makes it possible to introduce the co-operative system in any of the forms which the experience of Europe has shown to be practicable. In most of the States it is true that there are general laws of incorporation, but these do not meet the case in which a proprietor wishes to divide the profits with his workmen without making them partners, or giving them a voice in the management of the business. It is a subject which demands immediate attention, if it is expected to prosecute the iron business, or any other branch of industry, without the perpetual recurrence of strikes; and in order that the experience of older nations may be availed of, I have added to this report in an appendix (E) a transcript of the Prussian, French and English laws on this subject.

PRODUCTION OF IRON.

Originally the geographical position of the ore, and the natural avenues of transportation, determined the establishment of iron works, when the fuel employed was wood, which was to be found everywhere. But the demands of modern civilization soon outran the narrow bounds imposed by the supply of charcoal, and in our day the controlling element in the production of iron is the possession of mineral coal. And, throwing out of consideration the moderate quantity of iron still produced by charcoal, the iron business in Europe is found to be developed substantially in proportion to the quantity of coal possessed by the respective countries. A glance at the geological map of the world shows that within the limits of temperature favorable to active industry, the deposits of coal are widely distributed throughout Great Britain and the United States. In France there is but a limited area, and of irregular formation. In Belgium there is a larger coal field, but in veins of very moderate size. In Prussia, in the neighborhood of the Rhine, there is a small but valuable deposit of coal, while in Russia there is a considerable carboniferous area, the ultimate value of which is not yet well determined. The productive powers of these several coal fields are now pressed to limits approaching very nearly, if not quite to their ultimate capacity. In Great Britain the production in 1866 reached 101,630,500 tons; in France, between 11,000,000 and 12,000,000 tons; in Belgium more than 12,000,000 tons; and in Prussia, in 1865, 18,000,000 tons were produced.

The statistics procured at the Exposition have enabled me to construct the following table of the production of iron in the world in 1866, and there is every reason to believe that the figures given are substantially correct, as estimates were resorted to in only one or two cases, and those based upon former official returns:

Countries.	Pig iron, tons.	Wrought iron, tons.
England	4, 530, 051	3, 500. 000
France	1, 200, 320	844, 734
Belgium	500, 000	400, 000
Prussia	800, 000	400, 000
Austria	312, 000	200, 000
Sweden	226, 676	148, 292
Russia	408, 000	350, 000
Spain	75, 000	50, 000
Italy	30, 000	20, 000
Switzerland	15, 000	10, 000
Zollverein	250, 000	200, 000
United States	1, 175, 000	882, 000
	9, 322, 047	7, 005, 026

Allowing for the production in barbarous countries, and something for the use of scrap iron, it may be stated in round numbers that the production, and consequently the consumption of the world has reached 9,500,000 tons of 2,240 pounds each, or 21,280 millions of pounds; so that if the population of the world has reached 1,000 millions, the consumption is a little over 20 pounds of iron per head. A careful calculation, after allowing for the iron exported, shows that the consumption per head in England is 189 pounds of iron. The consumption in Belgium has reached about the same limits. The consumption in France is 69½ pounds per head, and in the United States not far from 100 pounds per head. If the industry of the whole world were as thoroughly developed as in Great Britain, the consumption of iron would reach nearly 90,000,000 tons per annum. If brought to the standard of the United States, a little less than 50,000,000 tons per annum would answer; or if to that of France, a little over 30,000,000 tons would be required; figures to be increased further by the steady increase of population in the world.

It will be interesting, therefore, to inquire into the sources of future supply possessed by the nations upon whom this great demand must come.

Sweden possesses exhaustless supplies of the very richest and best kinds of primitive ore, but she has no coal, and a heavy expense for transportation must be incurred in bringing coal and ore together, and, as a general rule, it is found more economical to transport the ore to the coal than the coal to the ore. The limits of the manufacture of iron by wood have long since been reached, and hence Sweden can only be looked to as a source of supply of ore to other countries possessing mineral fuel when their iron mines are too heavily drawn upon.

In Russia, also abounding in immeasurable supplies of ore, there is a possibility, but not much probability, that mineral coal may be developed to an extent sufficient for its own supply of iron. The production of charcoal iron is also capable of some, but not of indefinite extension.

The same remark applies to Austria and the states of the Zollverein. In Italy there is no coal, and hence its rich ores are in the same category as those in Sweden, only far less abundant. Algiers abounds in ore, which has to be transported to the coal. Spain is rich in ore, and has a carboniferous formation on its northern borders, but no attempts have been made to render it available for the production of iron. In France the present manufacture of iron is only maintained by the aid of the importation of coal to the extent of over 7,000,000 tons, and of 495,000 tons of iron ore in 1867.

In Belgium, the size of the coal-field, the vertical character of the veins, and their small thicknesss, render it impossible that there should be any very considerable extension of the business, at least if the supply is to endure for any protracted period. Already it is estimated that Belgium produces as much coal as France, two-thirds as much as Prussia, and one-eighth that of Great Britain, out of a coal-field only ninety-seven miles in length, and twelve miles in breadth at its widest point, and in veins of from thirty inches to three feet thick. Belgium is already an importer of ore, and although it is quite evident that it will be the seat of a vigorous and possibly increasing metal industry for years to come, it has no resources adequate for serious competition in the supply of the greatly increased quantities which the world will yet require.

Prussia has a somewhat larger supply of coal than Belgium, and is remarkably rich in quantity and quality of her iron ores, but it is scarcely possible that in the future she can do more than supply her own wants. Upon England, then, so far as Europe is concerned, still rests the great burden of supplying the world with iron, if the supply is to come from Europe at all. It has been seen that already nearly one-half the total consumption of the world comes from within her borders. In 1866 she was able to furnish 9,665,013 tons of iron ore, and only imported 56,689 tons.

A careful survey of the sources from which her ore is derived leads to the conclusion that in Wales the local supply is not adequate to the present consumption, and large quantities are transported thither from other parts of the kingdom. The natural limits of production have therefore been reached in Wales, although there will probably be a still further extension of the business in that region either with domestic or foreign ores, in consequence of the possession of enormous supplies of admirable coal available for the furnace without coking. The Staffordshire region, by common consent, has reached its culminating point; and a careful consideration of the local supply of carbonaceous ore in Scotland would seem to indicate that not much extension of the business is possible in that region, except at much higher prices than now prevail. The main reliance in Scotland has heretofore been upon its blackband iron ore, "and the development of its iron trade has been co-extensive with the exploration of that famous mineral, furnaces following everywhere in the wake of its discovery. The clay bands are in such small seams, and of such irregular character, that the business would soon languish and be greatly reduced if dependent upon them alone. The thickest and best seam of blackband, commonly called the 'Airdrie,' is now substantially exhausted, and the reliance is on seams of no greater thickness than eight inches. Blackbands are notoriously irregular, and are not found uniform in thickness; for example, the Airdrie blackband occupies but a small portion of the space allotted to it in the Lanarkshire coal-field. A more notable example of caprice of blackband is to be found in the slaty band, which occurs occasionally in patches of irregular thickness, sometimes six inches and sometimes six feet in thickness; but there is always something to mark its position, either a coal or iron stone. Indeed, all the iron stones in all portions of the coal-field are erratic. They are persistent throughout in no field, yet it is a singular fact that we have in all the fields blackband iron stone." This extract from a paper of Ralph Moore, a government mining inspector in Scotland, is made for the double purpose of showing how impossible it is that there should be any considerable increase in the annual product of Scotch iron unless foreign ores are brought to utilize the unlimited supplies of admirable coal which exist in that country; but with the further object of giving some information, which may be of use in the development of the blackband iron ore which has been recently discovered in Schuylkill county, in Pennsylvania, the value of which to the country can hardly be exaggerated, if it should prove to be in quantity and quality equal to its British prototype. An analysis of the best Scotch ore is here annexed—rather out of place, but too valuable as a guide to be dispensed with:

	Raw.	Roasted.
Protoxide of iron	49.82	27.10
Peroxide of iron	....	60.1
Lime	1.67	2.7
Magnesia	2.33	3.8
Alumina	1.52	2.4
Silica	2.40	3.9
Organic matter	7.60	....
Moisture	0.32	....
Carbonic acid	34.34	....
	100.00	100.00
Iron, per cent	38.75	63.1
Specific gravity	2.857	....

There still remains upon the east coast of England the great Cleveland region, and upon its west coast the Cumberland or red hematite region. The latter is now yielding about 1,400,000 tons of ore per annum, taken from beds of irregular shape and formation, in or adjacent to the limestone. There are certainly no signs of exhaustion yet apparent in this wonderful district, but all analogy leads us to doubt the permanency of these irregular beds, formed in pockets in the rocks, without any regular walls to indicate their continuity. Besides, the extremely good quality of this ore and the value of the iron which it produces will always restrict its use to those better purposes for which a high price is paid, and naturally withdraws those mines from any competition in the supply of the great mass of iron required by the world for ordinary purposes. Not so, however, with the Cleveland region, where the ores exist in beds of from eight feet to fifteen feet in thickness, in the lias or oolitic formation, extending over a tract of country forty miles in length and fifteen miles in width. This ore is lean and the quality of the iron inferior, but by the application of a high order of skill, a quality is produced sufficiently good for the ordinary purposes of commerce, and at a cost below that of any other locality in the world. The consequence has been that, since the erection of the first blast furnace in 1850, 125 furnaces have been erected, and fourteen more are now in process of erection; twenty-seven rolling mills, and a large number of foundries and iron ship-building yards are in operation, and cities have grown up with a rapidity and to a size that would strike even a western pioneer with surprise. The present production exceeds a million of tons per annum, and it is difficult indeed to assign any limits to its future growth.

But there is one limitation which applies to the whole question of the production of British iron, and that is, her ability to supply coal on the scale of consumption already beyond 100,000,000 tons per annum. This question has received the serious attention of the British Association for the Advancement of Science, and Mr. Gladstone, by one of those happy ellipses characteristic of men of genius, has coupled the extinction of the national debt with the exhaustion of the supplies of fuel, evidently acting under the idea that an honest man ought to pay his debts while his capital lasts. It is presumed, however, that there is still margin enough for the addition of the "Alabama claims" to the sum total of indebtedness, without seriously interfering with the means of payment which the coal-fields afford.

So far as the production of iron is concerned, and so long, at least, as any human being now in existence may have an interest in the question, I see no good reason to doubt why England should not maintain her position, as the source from which one-half the required amount will be obtained; but beyond this I do not think that she can or will go, from the intrinsic difficulties of producing the required supply of materials and labor, without an enormous increase of cost. There will, therefore, remain a very large deficiency, which must be supplied from some other source, and that source can only be the United States of America, for in no other quarter of the globe are the supplies of ore and coal sufficiently large, or so related to each other geographically, as to admit of its production, not merely within reasonable limits of cost, but on any terms whatever.

The position of the coal measures of the United States suggests the idea of a gigantic bowl filled with treasure, the outer rim of which skirts along the Atlantic to the Gulf of Mexico, and thence returning by the plains which lie at the eastern base of the Rocky mountains, passes by the great lakes to the place of beginning, on the borders of Pennsylvania and New York. The rim of this basin is filled with exhaustless stores of iron ore of every variety, and of the best quality. In seeking the natural channels of water communication, whether on the north, east, south or west, the coal must cut this metalliferous rim, and, in its turn, the iron ores may be carried back to the coal, to be used in conjunction with the carboniferous ores, which are quite as abundant in the United States as they are in England, but hitherto have been left unwrought, in consequence of the cheaper rate of procuring the richer ores from the rim of the basin. Along the Atlantic slope, in the highland range from the borders of the Hudson river to the State of Georgia, a distance of 1,000 miles, is found the great magnetic range, traversing seven entire States in its length and course. Parallel with this, in the great limestone valley which lies along the margin of the coal field, are the brown hematites, in such quantities at some points, especially in Virginia, Tennessee, and Alabama, as fairly to stagger the imagination. And, finally, in the coal basin is a stratum of red fossiliferous ore, beginning in a comparatively thin seam in the State of New York, and terminating in the State of Alabama, in a bed of 15 feet in thickness, over which the horseman may ride for more than 100 miles. Beneath this bed, but still above water level, are to be found the coal seams, exposed upon mountain sides, whose flanks are covered with magnificent timber, available either for mining purposes or the manufacture of charcoal iron. Passing westward, in Arkansas and Missouri, is reached that wonderful range of red oxide of iron, which, in mountains rising hundreds of feet above the surface, or in beds beneath the soil, culminates at Lake Superior in deposits of ore which excite the wonder of all beholders; and returning thence to the Atlantic slope, in the Adirondacks of New York, is a vast undeveloped region, watered by rivers whose beds are of iron, and traversed by mountains whose foundations are laid upon the same material; while in and among the coal beds themselves are found scattered deposits of hematite and fossiliferous ores, which, by their proximity to the coal, have inaugurated the iron industry of our day. Upon these vast treasures the world may draw its supply for centuries to come, and with these the inquirer may rest contented, without further question, for all the coal of the rest of the world might be deposited within this iron rim, and its square miles would not occupy one-quarter of the coal area of the United States.

With such vast possessions of raw material, we are naturally brought to the consideration of the elements which enter into the cost of producing iron in the United States, as compared with the other iron-producing countries of the world. And first, the distinction must be drawn between the cost determined by the quantity of labor expended in the production of a ton of iron, and the cost in money as determined by the price paid for the labor. The former is the absolute and natural cost, and is the only just standard of comparison between nations, if national wealth is defined to be the amount of capital in existence, plus the amount of labor available for production. The other is the artificial or accidental cost, of which, indeed, we may take advantage in our buying or selling, but forming no just standard of comparison in estimating the relative cost of production in different countries. There is a difference, familiar to all in the United States, between the cost of articles measured by gold or by currency, which makes it, for the time, easy to understand the difference in cost measured by money or by day's labor.

England, having the largest and most accessible stores of coal and iron ore, can produce a ton of iron with less labor than any other European nation; and hence it will be most profitable to institute the comparison of cost measured by labor, first, with Great Britain. In the Cleveland region, which is most favorably situated for the cheap production of iron, the cost of producing a ton of pig iron is about 40 shillings, which, at the average rate of wages paid around the blast furnace, is equivalent to 11 days' labor—that is to say, the labor of 11 men for one day. It is possible that in one or two works this may be reduced to 10 days, but in others it rises to 12 or 13. In the United States, the cheapest region for the manufacture of pig iron, as yet extensively developed, is on the Lehigh river, in the State of Pennsylvania, where, taking coal and ore at their actual cost of mining, pig iron is produced at an average cost of $24 per ton, which represents, at the present rate of wages, the labor of about 13 days. But when the iron business is established along the great valley which extends from Virginia to Alabama, the labor of bringing the coal and ore together will be considerably less than on the Lehigh river, and it is safe to say that there iron can be made in any required quantity, when the avenues of communication are sufficiently opened with as little labor, to say the least, as it can be produced in the Cleveland region. In France, Belgium, and Prussia, each now requiring a larger expenditure of human labor to produce a ton of iron than is required in England, there are no such possibilities of reduction, because every year their ore is becoming more expensive, and the cost of mining coal will increase more rapidly than in England, in consequence of the size and character of the veins. Hence follows the deduction that, if France, Belgium, and Germany, are to compete with England in the open markets of the world, the competition can only be maintained by the payment to labor of a lower rate of wages; or, to state it in another form, the greater the natural advantages possessed by a country for the production of iron, the larger will be the rate of wages paid to the workman; and this is found to be verified by existing facts.

From the statement published by Schneider & Co., at Le Creusot, it appears that the average rate of wages paid in 1866 was as follows:

	Francs.
Ore miners	3.3[illegible]
Coal miners	3.2[illegible]
Blast furnaces	2.9[illegible]
Rolling mill	3.8[illegible]
Machine shops	3.4[illegible]
Miscellaneous	3.0[illegible]

And the average price paid for the whole of the 10,000 workmen employed at this great establishment was 3.45 francs per day.

Unfortunately the rates paid for the specific branches of work are not specified, but at the iron works at Sireuil this information has been procured in detail:

	Francs per day.
Common laborers	2.50
Puddlers	8.00
Puddlers' helpers	2.50
Puddle rollers	5.00

	Francs per day.
ers	5.00
's	7.00
's' helpers	2.50
ing rollers	6 to 7
ıists	3 to 3.50
miths	....
s	5.00

outh Staffordshire, in 1866, the following rates were paid, as shown official returns published by the government:

	Per day.				
on laborers	2s.	6d.	to	3s.	0d.
rs	7	6	to	7	10
rs' helpers	2	6	to	2	11
rollers	9	0			
's	7	0			
's' helpers	3	6			
ing rollers	11	0			
ers	9	0	to	15	0
ıists	4	0	to	16	0
miths	4	0	to	5	0
s	7	6	to	8	6

mparison of these two tables will show that, for every franc paid nce, there is more than a shilling paid in England, and this cords with the general statement made by M. Schneider to me at usot. Assuming a little more than a shilling to the franc, 3s. 6d. y would appear to be the average rate of wages paid in England or in iron works of all kinds, skilled and unskilled, and in no part gland does it exceed 4s.

Belgium, according to Creed & Williams, in the coal mines the ing wages are paid:

	Per day.				
on laborers	1s.	6d.	to	2s.	6d.
rs of coal	2	6	to	2	11
cutters	2	6	to	2	11
or tree setters	3	1	to	5	0
s	2	11	to	4	2
tional men	5	0	to	6	0
At the blast furnaces:					
s	1	1	to	2	1
llers	1	4	to	1	8
on laborers	1	5	to	1	8
ce keepers	2	1	to	2	11
In the rolling mill:					
ers	4	2	to	5	0
rs	2	3	to	3	1

	Per day.
Rollers	4s. 2d. to 5s. 10d.
Helpers	3 4 to 4 2
Shearers	1 10 to 2 6
Common laborers	1 5 to 2 1

A comparison of these tables shows that the rate of wages is higher in Great Britain than in Belgium, and in France, being certainly in the order, and probably nearly in the ratio, of the natural advantages of these countries for the production of iron; and this view is confirmed by the selling price of iron in the respective countries, at the present time, when it is admitted on all hands that there is no profit to the maker.

The price of merchant bar-iron, at the works—

In England, is	£6 10 per ton.
In France	8 0 (200 francs) per ton.
In Belgium	7 0 (175 francs) per ton.

The difference between the cost of French iron and Belgian and English, aside from cost of transportation, which is very light, is compensated by the import duty, which, on iron from England and Belgium, amounts to sixty francs per ton. Independently of this tariff, which admits of a considerable importation of iron into France, it would not be possible for the iron business to be continued on any considerable scale, for the reason, as will be seen, that the wages are already at the lowest possible point consistent with the maintenance of human life in a condition fit for labor; the average earnings of all the workmen, skilled and unskilled, employed in an iron work being at the rate of 3.45 francs per day, or about 66 cents per day in gold; the great mass, however, of common labor receiving less than 50 cents per day in gold. In order to estimate the purchasing power of this sum, it is necessary to give the prices of the principal articles required for the support of life, and for this purpose I have selected the department in which Le Creusot is situated, as the proper locality for comparison, with the rate of wages there paid:

Wheat bread	0.25 francs per lb., equal to 5 cents in gold.
Rye bread	0.20 francs per lb., equal to 4 cents in gold.
Beef	0.65 francs per lb., equal to 13 cents in gold.
Mutton	0.75 francs per lb., equal to 15 cents in gold.
Veal	0.75 francs per lb., equal to 15 cents in gold.
Pork	0.75 francs per lb., equal to 15 cents in gold.
Chickens	1.00 to 2.50 francs, equal to 20 to 50 cents in gold.
Geese	3.00 francs, equal to 60 cents in gold.
Ducks	1.50 to 2.00 francs, equal to 30 to 40 cents in gold.
Butter	1.00 francs per lb., equal to 20 cents in gold.
Dozen eggs	0.50 to 1.00 francs, equal to 10 to 20 cents in gold.
Potatoes	0.50 francs per décalitre, equal to 40 cents per bushel.
Ordinary wine	0.40 francs per litre, equal to 5 cents per pint.
Beer	0.25 francs per litre, equal to 3 cents per pint.

House rent is cheap; a small, ordinary, but comfortable house, with a garden, renting for $16 per year in gold. Clothes are also cheap, costing not more than half the price of similar articles in the United States; but fuel is rather dearer on the average. It does not require any very extensive observation in order to verify the obvious conclusion deducible from the above figures, that the general condition of the working classes in France, from a material point of view at least, is simply deplorable. It requires the utmost economy on the part of a laboring man, and the united labor of his wife and his children, to keep his family in existence; and it is the accepted rule and practice for such a family to have meat but once a week; and any change in this condition of affairs, involving a change in the remuneration paid to the common laborer, would put it out of the power of the iron-masters of France to carry on their business, in competition with Belgium and England, in the absence of a higher tariff on imports. The existence of the iron business in France, therefore, as a national branch of industry, may be said to rest upon the elementary condition of giving meat once a week only to the great mass of laborers who are engaged in its production.

In Belgium, substantially the same state of affairs prevails. In the despatch of Lord Howard de Walden, the British minister at Brussels, to Lord Stanley, dated February 11, 1867, on the subject of Belgian industry, he says: "The characteristics of the Belgian workmen are steadiness and perseverance, combined with great intelligence in working after models; their habits are not so expensive as those of English artificers; their diet is more humble, they consume less meat, and their bread is seldom purely wheaten or white in quality; rye, and the cheaper quality of wheat called *'épeautre,'* enter in great proportion into the composition of the loaf; beer and spirits are both lower in price than in England; they seldom use tea, and the chiccory root constitutes a very economical and wholesome substitute for coffee. * * * * The system of schools for infants from two to seven years, and from seven to twelve years, is very general, and affords great facilities—the children being cared for—to both their parents to occupy themselves in daily service, and by combined industry to ameliorate the condition of their family. In all these respects, therefore, the necessaries of life being the base of wages, the Belgian enjoys advantages over the British workman."

From our American point of view, these "advantages over the British workman" in dispensing with meat and tea, and in substituting chiccory for coffee, and in appropriating the labor of both parents for a mere existence, are not so apparent. But we are naturally brought by it to consider the condition of the British laborer.

It has been seen that the natural advantages of Great Britain, in the possession of its vast stores of coal, afford a fund for the payment of better wages to the laborer in England than on the continent, and the British workman has not been slow to assert his rights to all he can get, and his physical condition is undoubtedly superior to that of his French and Belgian neighbors. If he is not better lodged, he is at least better fed, and in the iron works it is probable that the workmen generally get meat once a day. But, as a general rule, the labor of the women and children is required in order to eke out the subsistence of the family. In Wales women are extensively employed in the works, doing the labor for which a man would be required in America, and earning from ten pence to one shilling three pence per day, or rather less than half the wages that would be paid to a man for the same labor, which they perform equally well. In Staffordshire, and in the north of England, and in Scotland, women and children are still extensively employed above ground about the mines, and around the coal heaps at the mouths of the pits, the substantial result of which is that the labor of the whole family is procured for the sum which would be paid to its male head, if he alone labored for the support of the family, of course at a far lower cost in the resulting production of iron than would otherwise be possible. Restraining laws have been enacted in England of late years in regard to women and children, limiting the number of hours during which they may be employed, and also providing that they shall not be employed during the night, except in certain specified cases. But if the women and children were altogether withdrawn from those occupations, as they are in the United States, it would not be possible to produce iron, except at a considerable advance on its present cost.

Passing from the material to the intellectual condition of the workmen in France and England, the provision for the education of the children is upon a very limited scale indeed, and although there are creditable exceptions in particular localities, mainly due to the enlightened conscience of the proprietors, the great mass of the working classes out of the large cities are deplorably illiterate. In the department of Saône et Loire, where the works of Le Creusot are situated, and where the most commendable efforts are being made by Messrs. Schneider & Co. to educate the rising generation, it appears that 36.19 per cent. of those who were joined in marriage in 1866 could not write their names, and of the conscripts drawn for the army from the same department, in the same year, 24.51 per cent. were unable to read. And the same statistics show that, taken as a whole, in nearly two-thirds of France the number of those who cannot write their names on marriage is between the limits of thirty and seventy-five per cent. of the total number. This deplorable state of affairs has, of late, led to the establishment of schools for the instruction of adults, mostly voluntary, upon which there were in attendance during the present year 829,555 adults, of whom 747,002 were men and 82,553 were women. Of 110,503 who could neither read nor write on entering the course in October, 1866, 87,211 had learned to read by the 1st of April, 1867; 12,632 instructors have given their services gratuitously, and the whole movement, and the statistics above given, prove both the depth of ignorance into which the working classes have been plunged, and their earnest desire to emerge from it.

Surprise may be expressed that in view of the inadequate reward for labor in France, there has not been a larger emigration to our own country, where labor is so much better paid. The difficulties arising from the difference in language would of themselves be a great impediment to any extensive emigration movement; but there are impediments of another kind, not generally understood, which tend to prevent any relief to the laboring classes from this source. The law of "livret," as it is called, is peculiar to France. By its terms every workman is compelled to obtain from the police a kind of pass-book or register, in which his name, age, and occupation are inserted, and which he must show to an employer before being taken into his service, and no employer is permitted to receive into his works any workmen upon whose "livret" is not indorsed a full discharge from his previous employer. Provision is also made for the indorsement upon the livret of any indebtedness which may be due from the workman to the employer, and his debt therefore follows the workman as a mortgage upon his labor from place to place. Although in express terms there is nothing in the law which would warrant the employer in withholding an indorsement on the livret, yet in practice it is a restraint on his freedom of action to such an extent that workmen employed in the large works usually remain there permanently, so that there is but little change, and no opportunity whatever for practical combination in strikes and turnouts. The whole of this system is so peculiar, and throws so much light upon the power it gives to produce iron at a cost which would not be possible if the workman were a free agent, that I have deemed it best to annex to this report in an appendix (G) a translation of a circular which was obtained from the prefecture of police.

The moral condition of men is so dependent upon their physical and mental status that it is probably unnecessary for me to enlarge upon the obvious conclusions that might be inferred from the facts above recorded; but the conviction in my own mind was so profound, after a very careful survey of the whole field, that I deemed it my duty to accept an invitation to testify before the Trades Union Commission in England, in the hope that a full discussion of the physical and moral elements involved in the organization of industry would result in the ultimate elevation of the working classes of Europe to such a standard, at least, as would render the conditions of competition between our own country and Europe more just and equitable. It is quite evident that in the effort to produce cheap commodities, and to undersell each other in the markets of the world, the rightful claims of humanity have been disregarded to such an extent that the reorganization of labor, in its relation to capital, is felt by all thoughtful men to be an imperative necessity.

It cannot be that the aim of society is only to produce riches. There must be moral limits within which the production of wealth is to be carried on, and these limits have been and are being so obviously transgressed that a spirit of discontent pervades the entire industrial world; and in the very countries where this competition has been pressed to its utmost limits capital has ceased to become remunerative, although humanity itself has been sacrificed to its demands. The evidence which I gave before the Trades Union Commission was delivered in this spirit of deep concern for the welfare of the working classes; and inasmuch as a few incidental sentences repeating statements which had been made to me in regard to the Pittsburg strike, but of no consequence in reference to the main question, were seized upon by the London Times as a groundwork for characteristic unfavorable comment on American institutions, and some feeling was excited among the working men in the United States in reference to these misrepresentations, against which, it will be seen, I took occasion to protest on my second hearing before the commissioners,[1] long in advance of any knowledge on my part of the effect produced by them at home, it is deemed proper to state that the evidence so given, in Europe at least, was universally regarded as an appeal in behalf of the working classes, not in defence of any violation on their part of the fundamental principles of social science, but in assertion of their just rights to education, domestic happiness, and adequate remuneration for labor.

There are some statements made thereon, of no great importance in themselves, based upon information derived from other parties, on whom I had reason to rely, which may have been erroneous; but in all such cases, where I did not speak of my own knowledge, I expressly so stated, and this was particularly the case in regard to the Pittsburg strike, where the evidence shows that I expressly disclaimed personal knowledge of the facts; but I desire now to state that the information was derived from a resident of Pittsburg in whom I had reason to feel entire confidence. In my second evidence before the commission, it will be seen[2] that I took occasion to correct some errors of this kind, having in the mean time received more correct information. There are also some replies bearing on the nationality of workmen, elicited in answer to questions over which I had no control; but in so far as they may appear to be invidious to any one nation, there is no real cause for complaint when the answer is understood. For example, the statement that the Irish are rarely first-class puddlers was made as a matter of fact in nowise depending on the land of their birth, but because they do not begin to learn the business until they arrive in America, full-grown adults, whereas in England the education of the puddler begins in boyhood, and is pursued for many years before he takes a furnace. The same answer would, therefore, have been given to the same question, if asked with reference to the natives of any other country who had not learned the business from boyhood.

But if, in comparison with the ample provision made in our country for the education of the masses, the arrangements in France and England are upon a meagre scale, the opportunities for scientific and technical

[1] See Appendix H. [2] Ibid.

instruction, in France especially, are of a far more complete and generous character. For the governing classes, or for those who, rising out of the lower ranks, are educated to fill positions of trust and responsibility, there exists a series of educational establishments of so thorough a course in their respective departments as to exhaust all that experience and science can do for the preparation of engineers and conductors of industry. The Ecole Centrale des Arts et Manufactures at Paris, the Conservatoire Impériale des Arts et Métiers, several large agricultural schools, L'Ecole Impériale des Ponts et Chausées, L'Ecole Impériale des Mines, L'Ecole Impériale de Commerce à Paris, the three schools des Arts et Métiers at Chalons, Aix, and Angiers, the School of Mines at St. Etienne, the School of Watchmaking at Cluses, of the Mining Classes at Alais, the Naval School at Marseilles, are all sustained by the government in the interests of industry and commerce, and give to French industry that intelligence, science, and skill, which, in the Exposition, extorted universal admiration, and the general confession that its products, even in machinery and metals, were up to the highest standard of excellence. Similar schools in the United States ought to be the fruit of the great endowment of lands given to the States by Congress for the establishment of institutions designed to teach mechanical and agricultural science and art; but it is to be regretted that, at the present time, the application of this grant has not been so directed as to secure such a result, and we must console ourselves with the reflection that, if we are deficient in the higher education necessary for the best industrial development, we have in a measure supplied its place by a general diffusion of knowledge, which, evoking the ingenuity and individuality of each workman, has rendered it less necessary than in countries where the masses are in ignorance. But it cannot be disputed that this individuality and ingenuity in our American character will be more valuable and powerful when directed by the highest order of intelligence and thoroughly trained scientific leaders.

It is obvious that the abnormal rates for labor which we have been considering cannot prevail in any one branch of industry alone, but must extend to all, as labor, like water, must seek a general level in each community governed by the same laws and subjected to the same influences. All articles of commerce are, therefore, produced below their normal cost—that is, the cost which would be possible if the fundamental laws of humanity were not violated in the employment of women and children, and the payment of a rate of wages to the common laborer inadequate for the proper support and culture of the family. In those commodities which require in the United States more human labor for their production than is necessary in Europe, where labor is so inadequately paid, we have, perhaps, no other interest than a general concern in the welfare of the human race; but so far as iron is concerned, from the fact that we can produce it with as little consumption of human labor as any other nation in the world, the case is different, because there is no absolute loss of wealth, and no misapplied power in its production; and the only question to be discussed is, whether it shall be taken out of the general category of manufactures not so favorably placed as to the cost of production, and by positive legislation placed in the same condition as it would have occupied with reference to foreign competition, if the rate of wages in other countries had never been reduced below their normal standard.

We have seen that the cost of making iron in England, Belgium, and France, at the present time, varies from £6 10*s*. to £8 per ton, and £1 additional suffices to pay its cost of transportation to the seaboard of the United States. At these ports American iron cannot possibly be delivered at a less cost than $60 in gold against $40 in gold for the foreign article, and the entire difference consists in the higher wages, and not larger quantity of labor required for its production in the United States, where the physical, mental, and moral condition of the working classes occupy a totally different standard from their European confreres, and where the wages cannot be reduced without violating our sense of the just demands of human nature.

At the same time it is to be observed that the business is so far overdone in Europe that no profit can be realized by the capitalist, except in special cases, for which adequate reasons can be given. The actual remedy for this over-production would be to withdraw the women and children, as we do, from this class of industry, whereby the production must be reduced, the rate of wages raised, the cost and the selling price increased, capital become remunerative, and the ability to procure iron, made cheap by its adulteration with the violated laws of humanity, be forever extinguished. To what result the general discussion which this subject is now receiving in Europe will lead it is not easy to decide; but it is a curious phenomenon to listen in France to the loud complaints which are made against the competition of Belgium in the manufacture of iron, and stranger still in England to the same complaint, and the broad declaration that it will not be possible to do anything for the education and elevation of the working classes without exposing their manufacturers to ruin in consequence of the competition with the worse paid and worse fed labor of Belgium. The truth is that the whole system is false, and now, when pressed by the energy, enterprise, and competition of the age to its legitimate results, humanity is in rebellion, and there is a general cry from all classes, laborers, employers, philanthropists, philosophers, and statesmen, alike for relief.

The necessity for this relief becomes painfully apparent when the poor-law returns made in England are carefully examined, from which it is evident that there is an army of paupers pressing upon the occupations of the common laborer, and striving to push him over the almost insensible line which divides these two classes from each other. It is not possible that the laborer should receive more than bare subsistence wages, and there can be no relief for his patient suffering, so long as there are thousands who, unable to earn any wages at all, stand ready to fill up every gap in the ranks of industry; and to the honest laborer himself, standing on the edge of this line, over which he is liable at any moment to be forced into the ranks of pauperism, the anxiety and miserable state of uncertainty for himself and his family must be fatal to all rational happiness, and is well calculated to drive him into vicious indulgences and temporary excesses whenever a transient opportunity is afforded, as a momentary relief from a condition of hopeless misery.

From the returns made to the British Parliament as to pauperism in the month of September, A. D. 1867, it appears that out of a population of 19,886,104, dwelling in the area for which the returns are made, 872,620 persons were on the list of paupers, supported by public charity, of which number 129,689 were in the workhouses, and 738,726 were relieved in their own houses. This latter portion constitutes the army which substantially regulates the rate of wages for labor, as they are ready, to a greater or less extent, to take any vacant place which may offer itself. And this state of the case exists not in mid-winter, but just after the close of the harvest, and the returns show that the evil is an advancing one, as there is an increase of 27,521, or 3.3 per cent., in 1867 over the corresponding week in 1866. And a study of the tables which are hereunto annexed (Appendix I) shows the largest rate of pauperism is in the manufacturing and not in the agricultural districts.

By another parliamentary return, which is also annexed, (Appendix I,) it appears that the average number of scholars attendant upon the schools under government inspection in the year 1866 was 871,309 in England and Wales, showing this suggestive fact, that the paupers receiving public relief, and the children receiving instruction in schools aided by the public funds, were about equal in number. This statement alone, if other evidence were lacking, would serve to prove that the working classes of Great Britain have not yet achieved the position in point of education and social comfort to which humanity is entitled. Nor can it be alleged that this is due to any deficiency in the resources provided by nature for the reward of industry. The coal and iron ore mines of England afford the most magnificent fund to be found on the face of the globe for the abundant remuneration of the capital and labor engaged in their development, and every class in the community, except the operatives themselves, have enjoyed a bountiful return for their interest in this national endowment. The landowner has been largely paid, not only by the royalties derived from the minerals, but in the enormous increase in the value of the soil by the rapid growth of population engaged directly and indirectly in the manufactures based on their consumption. The capital invested in manufactures in Great Britain has, in the main, reaped a most abundant reward, and the general result has been an accumulation of capital in the hands of the higher and middle classes unequalled in the history of mankind.

That the working classes have not been equally well rewarded is due simply to the improvident and even reckless manner in which these great natural resources have been employed, giving rise to a competitio unlimited by any other consideration than the immediate profit to b derived by the capital invested in the business. Of course, the less th rate of wages, the longer the number of hours of work to be got fro the laborer, the greater the number of women and children that coul be employed, the lower will be the cost of the product, and the mor decided the ability to undersell all foreign competitors in the markets o the world. Hence, in the absence of restraining laws and an enlighten conscience on the part of the operators and manufacturers, and in th presence of a large population in a restricted area, governed in the inte ests of special classes, it was inevitable that the superior natur resources of Great Britain should be used, as they have been, rather crush out foreign competition than to elevate the working classes; a this very attempt to undersell foreign nations in their own mark necessarily involved the lowest possible rate of wages in those countr consistent with mere existence; reacting, in turn, upon the Engli labor market, and compelling lower rates of wages than would otherwi have been required, if the aim of the nation had been directed to t payment of the largest possible compensation to its own working class rather than to the control of the markets of the world even at t expense of humanity itself.

The possession of these wonderful deposits of coal and iron, as a fun for the payment of adequate wages to labor in Great Britain, is equiv lent to our virgin soil in the United States, enabling both nations to p the highest possible rate of wages consistent with the conservation capital; but this advantage in Great Britain has been deliberately a recklessly thrown away by a competition between the English manu turers themselves, resulting in an over-production, and compelling steady pressure upon the wages of labor, in order to keep up the p duction and secure larger consumption by lower prices for the commo ties. It is a mistake to suppose that this reduction in price has b caused by the competition of foreign nations with Great Britain, for have seen that France cannot produce enough iron for its own consu tion, and that Belgium only turns out one-tenth as much iron Great Britain, and is therefore governed as to price solely by the rate which Great Britain is willing and able to furnish the remaining n tenths. If it were possible for Belgium to alter the ratio of producti she might in the long run make the price for the total product; but i simply ridiculous to apprehend, in view of the natural resources of t two countries, that any such change can ever be effected.

The most interesting industrial and social question of the age is, the fore, the policy which will be pursued by Great Britain in the admi tration of its mines of coal and iron. And the royal commission, making an official inquiry into the exhaustion of the coal fields, will far short of the real scope of the question if it fails to investig whether, by wise and suitable regulations, the annual product of c cannot be so regulated as to secure a far better remuneration to the labor engaged in its production than it has heretofore received. I am perfectly aware that such regulations must necessarily be restrictive in their character, and, at the first glance, will appear to be at war with the commercial policy of free trade advocated in Great Britain. Very little reflection, however, is required to show that by far the greater portion of the legislation of all enlightened nations is necessarily of a protective and restrictive character; and at this day no enlightened statesman would advocate the deliberate sacrifice of local advantages for the sake of any mere abstract theory, which might be ever so well founded in reason, but fails to be applicable in the presence of exceptionable facts and resources. The protection of life, liberty, property, and social order, the title to lands and personal property, rest entirely upon protective laws; and all provisions for the protection of capital and health and the establishment of police are so many restraints upon the natural freedom of the individual; and surely legislation looking to the wisest possible use of national resources and the prevention of the waste or misapplication of the raw material, upon which the structure of the national industry and prosperity and the welfare of the working classes rest, is not merely a natural but a necessary step in the progress of industry and the development of civilization.

In no country in the world are so many proofs of the wisdom of this course to be found as in the history of British legislation in reference to the working classes during the last 35 years. The repeal of the corn laws was a measure of eminent protection to the working classes, relieving them of the taxes imposed upon food for the benefit of the landowner alone; because the condition of the agricultural laborer could not be made worse, but could only be improved by any change. The series of laws regulating the employment of women and children in factories and mines are not merely highly restrictive, but by common consent have produced the happiest results on the moral and physical condition of the working classes. The laws recognizing the legal existence of friendly societies; for the encouragement of building associations; the conversion of the post offices into savings banks for the working classes; for the granting of annuities and life assurance guaranteed by the government to the working classes, on the payment of small periodical instalments; for the encouragement of co-operative stores and associations; for "partnerships of industry," in which the workman is allowed to have an interest in the profits of the business without becoming liable as a partner for the debts; the statutes authorizing the establishment of free reading rooms, libraries, and museums, by a vote of the rate-payers in any borough, town, or city, constitute a course of wise legislation unmistakably protective, restrictive, and enabling; persistently advocated and successfully established by the most sagacious, liberal, and philanthropic statesmen of the present age, and resulting in so marked an improvement in the condition of the working classes, accompanied classes, and above all the considerations of independence, essential to the dignity of the American republic and the welfare of mankind. But in the discussion of this question, and in the legislation which may be proposed to meet the best interests of the nation, in regard to a supply of iron and steel, the broad distinction which exists between the nature of the question in Europe and the United States must never be lost sight of. On the continent, protective duties on iron are imposed in order to counterbalance the superior natural resources and advantages of Great Britain for the production of iron, and not to secure higher wages to the laborer; whereas, in the United States, protective duties, if imposed at all, are not necessary because our natural advantages for making iron are inferior in any particular to those of Great Britain, but simply because the wages of labor are fixed upon a most just and liberal scale to the workmen in the first instance, and by the law of equivalents to the whole industrial force engaged in the great work of production, of whatever form and nature.

If the facts and suggestions contained in this report, the result of half a year of careful study of the Exposition, and the knowledge which it enabled me to acquire in reference to the social condition of the working classes in Europe, shall in any way aid Congress in arriving at a judicious solution of these grave questions, involving so many and such varied interests, and if, as I hope, the terrible evils of pauperism shall be even for a time, and possibly forever, averted from our own country by legislation based upon sound, social, and economical principles, I shall cease to regret the strange and cruel misrepresentations to which I have been subjected among the working classes, in whose behalf mainly the duty confided to me was undertaken.

Whatever policy may be finally adopted with reference to American industry, it is a source of profound satisfaction, and should be a subject of general congratulation, that a careful survey of the natural resources of those nations who stand in the van of European progress and civilization justifies the declaration that the great problem of democratic institutions is being solved in a land having, in addition to a fruitful soil, the largest and best supplies of the fundamental elements upon which industry, progress, and civilization are based; and that there is good reason to hope that here it may be shown how wealth may be created without the degradation of any class which labors for its production; the only advantage (if advantage it may be termed) possessed by Europe over the United States, for the cheap production of iron and steel, being in the lower and inadequate rate of wages which there prevails, and not in any superior natural resources in ore, fuel, or geographical position.

ABRAM S. HEWITT,

United States Commissioner to the Universal Exposition of 1867.

Hon. WILLIAM H. SEWARD,

Secretary of State.

PARIS, *November* 30, 1867.

SECTION II.

BESSEMER STEEL.

THE BESSEMER PROCESS IN VARIOUS COUNTRIES.

The undersigned has the honor to submit a special report upon "Bessemer steel," prepared under his direction by Frederick J. Slade, scientific assistant to Committee No. 6, and duly approved by the committee and ordered to be laid before the Commission.

ABRAM S. HEWITT,
U. S. Commissioner and Chairman of Committee No. 6.

PARIS, *June* 22, 1867.

The Paris Exposition affords valuable information in reference to the capabilities of the Bessemer process for the production of all grades of metal, from a near approach to wrought iron to the hardest and finest kinds of steel. A comparison of the specimens sent from the various countries shows that the quality of the metal produced depends chiefly upon the nature of the raw materials used, and accordingly it is only in those countries where the very best ores and purest coals are employed that we find the finer grades of steel produced.

It will, perhaps, be most instructive, therefore, to examine the manner in which this process is conducted in each country separately, and to trace, if possible, the relation between the nature of the finished products and the materials and modes of working employed in their manufacture. We begin naturally with

ENGLAND.

The iron almost exclusively employed in England for the pneumatic process is obtained from the Cumberland district, and is derived from red hematite ores. Dr. Percy, in his well-known work on metallurgy, gives the analysis of two specimens of these ores:

	I.	II.
Sesquioxide of iron	95.16	90.36
Protoxide of manganese	0.24	0.10
Alumina	.....	0.37
Lime	0.07	0.71
Magnesia	.....	0.06
Phosphoric acid	trace.	trace.
Sulphuric acid	trace.	trace.

	I.	
Bisulphide of iron	trace.	
Ignited insoluble residue	5.68	
	101.15	1(
Silica	5.66	
Alumina	0.06	
Sesquioxide of iron	.....	
Lime	.....	t:
	5.72	
Iron, total amount	66.60	(

The blast furnaces in which these ores are smelted average abo feet in height and 15 feet diameter of boshes, and are in most cases o topped, the opinion among the iron masters being that the quality o iron is injured by any attempt to draw off the gas. At some furn however, this notion is abrogated, and the waste gases are utilize heating the blast. Among these are the furnaces of the Barrow Hem Iron and Steel Company, the West Cumberland, and the Wigan Iron Coal Company's furnaces. The quality of pig produced at these l works does not perhaps stand invariably as high as that of the W haven Hematite Iron Company, (Cleator,) the Workington Iron Comp or the Harrington, but if there is a difference it is easily accounted f the quality of the materials used, without the necessity of resort t supposition of an injurious effect from utilizing the escaping gas.

The fuel used at the furnaces in the Cumberland district is the Newcastle coke, which is remarkable for its hardness and freedom sulphur. Dr. Percy gives the percentage of sulphur as 0.8 and of 4.45. No charcoal pig is made in England for the Bessemer process. fluxes employed are a limestone quite free from phosphorus, and a po of black shale from the coal beds, consisting of clay and carbonac matter, without any appreciable amount of sulphur. The percenta iron indicated by the above analysis, viz., from 60 to 70, appears to fair average, and the ores are not calcined. As it is necessary that iron should be as gray as possible, not less than 30 hundred-weig coke are used per ton of iron produced, and a charge is about 50 h in coming down through a furnace of the dimensions given above. yield from such a furnace is 250 tons per week.

The blast is under a pressure of 3¾ pounds, and is heated to from to 750° Fahrenheit. From four to six tuyeres are usually emplo No. 1 iron for the Bessemer process from these furnaces brings 90 s ings per ton at the works, and No. 2, 10 shillings per ton less.

The Wigan Iron and Coal Company, Lancashire, produce an iron w is used to a considerable extent for the process, but does not ran high as the Cumberland irons. The coal as mined would be quite for use in the production of such a grade of iron, as it is materially contaminated with sulphur, but this is almost entirely removed by washing the fine coal, the pyrites settling by their superior weight, while the pure coal is carried on to receiving beds by the current of water, and the purified residuum is then converted into coke, yielding a tolerably strong product. This company have just erected a number of new furnaces much above the usual size for this kind of iron, viz., 80 feet high and 24 feet diameter of boshes, and these are provided with a cone and bell arrangement for taking off the gas.

Forest of Dean iron, made from brown hematite ores, is frequently used in small quantities in admixture with other irons for the purpose of maintaining the heat of the charge, which it tends to do. It is apt, however, to contain too large a percentage of sulphur to work well alone.

Another brand which is said to work well is Weardale, an iron made from spathic ores. It is unusually rich in manganese, and owes its excellence chiefly to that fact.

The following analyses exhibit the characteristics of some of the more usual brands of iron employed:

	Cleator.	Workington.	Weardale.	Forest of Dean.
Carbon, (graphitic)	4.007	3.14	3.24	3.25
Silicon	1.752	3.12	1.80	1.36
Sulphur	....	0.05	0.04	0.037
Phosphorus	0.049	0.03	0.19	....
Manganese	....	0.02	1.45	....

The analysis of Weardale is taken from Percy's Metallurgy; the others were furnished to the writer from different sources in England.

The presence of silicon in the iron causes the charge to work hot in the converter, and it is usual therefore to mix an iron rich in this element with others containing a less quantity, and which have a tendency to work cold and become pasty. As a rule Workington iron contains more silicon than any other in use for the process, and being moreover an excellent iron is largely used. It is, however, from the very fact of its working so hot, seldom employed alone, as it cuts the moulds badly in pouring.

Sulphur and phosphorus are the most injurious elements found in the pig, because the pneumatic process is powerless to remove them, and the quality of the steel is materially affected by their presence. An effectual means of eliminating these substances, in the process of conversion, would be one of the most valuable discoveries of the times.

It is usual among all the steel makers to mix several different brands of iron where a uniform and good quality of steel is desired, but there seems to be no definite mixture which is agreed upon as best. The principle appears to be to form the larger portion of the charge of the better brands of Cumberland hematite, and to add as correctives smaller percentages of other irons. The following will serve as examples, the fi having been given to the writer by Mr. F. Preston, late managing dir tor of the Lancashire Steel Company, and the other being from the boo of another large firm:

I.	
Workington	45
Harrington	40
West Cumberland	10
Wigan	20
Weardale	7
Forest of Dean	3
	120
Spiegel	$7\frac{1}{2}$
	$127\frac{1}{2}$

II.	
Cleator	[illegible]
Workington	[illegible]
Harrington, (No. 1)	[illegible]
Harrington, (No. 2)	[illegible]
Forest of Dean	[illegible]
Wigan	[illegible]
	[illegible]
Spiegel	$6\frac{1}{4}$ or [illegible]

For forgings, such as axles, tires, locomotive crank shafts, &c., no but No. 1 iron is commonly used, but for rails a greater or less amou of No. 2 is added, in order to reduce the cost as far as possible.

The amount of this quality that may be used will of course depend the character of the iron.

The iron as a rule is melted in reverberatory furnaces, but at five wor cupolas have been substituted with apparently good results. These are

The Manchester Railway Steel and Plant Co.;

Messrs. Chas. Cammell & Co., Penistone;

The Bolton Iron and Steel Co.;

The Barrow Hematite Iron and Steel Co.;

The Mersey Iron and Steel Co., Liverpool.

At the latter a cupola is also employed for melting the spiegeleise At the first-mentioned works Woodward's patent steam-jet cupola employed, it is stated with a consumption of coke as low as $1\frac{1}{4}$ pound p hundred-weight of iron. At the others, Ireland's upper tuyere cupol are employed. These cupolas melt very rapidly, and are sufficient capacious to hold an entire charge in the portion below the upper row tuyeres. The size erected for a five-ton plant is seven feet in diamet and will melt five tons of iron in three-quarters of an hour. In workin the charge is weighed when it is put into the cupola, and, as it melt remains in the bottom till the whole has been fused, when it is tapped into the converter. They generally require cleaning once in 24 hou Of course where cupolas are used, much greater care has to be exercis in the selection of the coke, as fuel which might be used in the air fu naces would destroy the quality of the iron if burned in contact with The opinion among those who employ the cupolas is, that it is quite p sible to find a coke sufficiently free from sulphur to yield a satisfacto result. At the Barrow works, preparations had been made to conv the molten metal directly from the blast furnaces to the converters, b after a number of trials it was found that the uniformity of the metal could not be relied on, and, in consequence, the attempt was abandoned, and cupolas erected instead, to remelt the pigs. The converters at the majority of the works have a capacity adequate for a yield of five tons of steel, or allowing one-sixth for waste, which may be taken as a fair average, for six tons of molten iron. At Barrow, however, three seven and a half ton vessels have been erected, besides their five-ton plant, and at Messrs. John Brown & Co.'s a pair of ten ton vessels have been in use more than three years. The material commonly employed for lining the vessels is ganister, a highly silicious substance, found at Sheffield. Other materials have been tried at some works, as, for example, at Dowlais, with apparently great success. A pair of vessels, at the works just mentioned, had recently stood 300 blows each, without relining, and were still apparently in good condition. This is much above the average endurance of the refractory linings. The destruction of tuyeres is an important item in the expenses of the process. The average life of these is seldom over five blows, and the failure of one during a blow is often the cause of considerable loss, either by damage to the vessel or by injury to the contained charge.

In the general arrangement of the Bessemer plant, very few changes have been made from that planned by Mr. Bessemer and contained in the drawings supplied to his licensees. A pair of converting vessels usually placed opposite to each other, but in some cases side by side, stand at the side of a casting pit, sunk a few feet below the general level of the floor. These vessels are mounted on trunnions, and are revolved on them by means of a rack and pinion operated by hydraulic pressure. The melting furnaces are placed in a room having a considerably higher floor level than the converting room, so that the melted metal may be run by its own gravity into the mouth of the converter, when the latter is turned down suitably to receive it. In the centre of the pit is a vertical hydraulic piston or crane, carrying at its upper end a platform, at one end of which is a ladle sufficiently large to hold the contents of the converter at the end of the operation. The platform is furnished with gearing, so that it may be easily revolved to bring the ladle over each ingot mould successively, the latter being arranged accordingly in the arc of a circle near the side of the pit, which here has the same form. The ladle is provided with a nozzle and stopper in its bottom, by means of which the flow of the steel is regulated. Two hydraulic cranes, consisting simply of vertical pistons, carrying a long horizontal jib with a rolling carriage, to which a chain and hook is attached for lifting the ingots, are placed near the edge of the pit, about opposite the centre of the converters, and serve also to lift off the various parts of the latter when required for repairs. The blast valve and hydraulic apparatus pertaining to the converters are worked from a valve stand, placed at a suitable distance from the pit, the cranes being operated by a valve directly attached to them, so that the attendant boy may the better see what he is required to do, and the whole of the manipulation of the vessels, ladles, and ingots, gives an ease of working and a perfection of control, with economy of labor, which should lead to the more general application of hydraulic power to other departments of industry in which large masses have to be dealt with. The water pressure used for the purpose is about 300 pounds per square inch. The sizes of ingots most commonly cast are, for rails, about 10 inches square, for locomotive crank shafts, ingots of a rectangular section, say 22 inches × 16 inches, and for other forgings according to the size and nature of the work, the moulds having a weight about equal to that of the ingots. At some works, the plan is adopted of testing a sample of each blow for carbon, and classifying the metal according to the result of this test. By this means much greater uniformity in the finished work is obtained, and in the present state of our knowledge of the process, this is a very necessary means to secure this end, and should be more generally adopted. The process employed was introduced from Sweden, and is exceedingly simple in its nature. It consists in dissolving a known weight of metal, in the form of drill chips, or some other finely divided state, in nitric acid, of the gravity 1.2. The solution will have a brown color, more or less deep according to the percentage of carbon contained in the metal. A standard color, corresponding to a known percentage of carbon, as determined by direct analysis, is first established, and the color of the solution to be tested is made to agree exactly with this by the addition of a certain quantity of acid or water. That this, which is the readiest method of producing agreement, may be employed, the color of the standard solution must be light. The water is added to the solution in a graduated test tube, so that the exact proportion of water relatively to the original solution may be read off with ease, and if, for example an equal bulk of water requires to be added to make the color the same as the standard, the percentage of carbon in the specimen under test must be just double that of the standard. As a solution of steel in acid would in the course of time change its color, an exact imitation of it is made by dissolving burnt sugar, and this is kept hermetically sealed for comparison. To secure a light standard color, it is not necessary that the piece of steel dissolved should contain a small percentage of carbon, but a larger quantity of acid may be used in a known proportion, say twice or three times the required amount, and the corresponding percentage of carbon will be equally well ascertained. This test is easily and quickly applied, and the variation of color being considerable, gives results sufficiently accurate for the purpose of a proper classification of the ingots according to the purposes for which they are suited.

The principal uses to which the Bessemer metal is put in England, are the manufacture of rails, tires, axles, machinery forgings, and boiler plates. The total amount produced may be judged from the fact that the qu tity made per week at the works of Messrs. John Brown & Co., limit and Messrs. Chas. Cammell & Co., limited, is stated to be 600 or 700 tons each. The number of establishments at which the process is in operation is about 15, and the number of converters employed upwards of 50. The chief market is for rails, and a large proportion of the orders are for *American roads*. In England, not much ordinary line has been laid with steel rails, but on most roads those portions which are exposed to excessive wear, such as stations and inclines, are being relaid with steel. The public are already familiar with the vastly superior endurance of steel in such situations, and nothing need therefore be said here on that point.

MANUFACTURE OF STEEL RAILS.

It is usual, as already stated, to cast a 10-inch square ingot for rails. At most works, this is heated in a reverberatory furnace and hammered down to 7 inches square. At some prominent establishments, however, this process is dispensed with, and a 10-inch ingot is taken directly to the rolls and rolled down to 7 inches. At Crewe, Mr. Ramsbottom employs a heavy cogging machine for the same purpose. This is simply a form of reversing rolls made exceedingly large, and only performing a part of a revolution at each pass of the ingot. It is stated that the rails made from unhammered ingots stand equally good tests with those which have first undergone hammering.

The substitution of rolling of course cheapens the manufacture and reduces the amount of plant necessary, as well as the number of hands required. It is usual after the ingot has been brought from 10 inches down to 7 inches to put it back into the heating furnace for a short time, to bring it up to a heat sufficient to carry it through the remainder of the process. With hammered ingots it is usual to allow them to become cold after hammering, and to reheat them entirely anew, since it is not easy to regulate the heats so as to have the hammer supply hot ingots to the furnaces for the rolling mill. This, of course, involves a further additional expense in the use of the hammer. In heating the ingots care has to be taken that the heat is not forced so as to burn the steel, and ample time must be given for it to "soak." Practically about four heats are obtained in twelve hours, where with iron seven or eight could be got. When the ingots are rolled from the cast size it is usual to provide larger furnaces and a greater number for the first heat than for the second, as the fewer and smaller ones will work off the same number of ingots, on account of the shorter time necessary to bring them to the required heat. At the Dowlais works, for example, there are seven furnaces holding seven ingots each for the first heat, and but four holding four apiece for the supplementary heating.

The usual size of rolls for steel rails of the English (80 lbs per yard) or other pattern is from 22 inches to 24 inches diameter. In some cases, however, smaller sizes are in use, as at Crewe, and at the Mersey iron and steel works, at the latter of which only an 18-inch train is employed. These, however, are trains which were originally intended for rolling iron rails, and have been compelled to do service for steel.

The speed with rolls of the first mentioned sizes varies from sixty to forty revolutions per minute; the former extreme, however, seems preferable. The drafts on the rolls are made somewhat lighter and more numerous than for iron—say two more grooves for finishing.

At several works reversing rolling mills have been erected, to avoid the necessity of lifting the ingots in returning, and also to save time by operating on the ingot when moving in either direction. The usual plan has been to effect the reversing by engaging by means of a clutch gears running in opposite directions. This necessarily brings a severe shock on all the machinery, especially at high speeds, and in some cases where the arrangement has been introduced it is not used, the mill always running in one direction, and the rolling being carried on in the usual way. Mr. Ramsbottom has constructed and patented a reversing mill, which he uses for rolling locomotive frame plates, at Crewe, which is free from this objection. He drives his rolls by a pair of engines resembling a set of locomotive engines in most of their details, and without any fly-wheel. These work at a high speed, and are geared to the rolls in such a manner as to reduce the speed to the required amount. The link motion is thrown up or down in reversing by a hydraulic piston easily set in motion by the attendant, and by these means the engines can be reversed seventy times per minute and entirely without shock. This principle for reversing would appear much preferable to the use of a clutch. The employment of a fly-wheel is not found necessary, as the engines, in virtue of their high speed, contain power sufficient to overcome any obstacles within the limits of safety to the rolls, beyond which it is better that they should stop. Mr. Ramsbottom has adopted in this set of rolls a thorough application of hydraulic power for all the operations of manipulation, and has thereby obtained great facility of working and economy of labor. Instead of the reversing principle, a steam or hydraulic lifting gear is used at some works for raising the ingot to the level of the top of the upper roll, and by many this is preferred to reversing.

The Siemens furnace is coming extensively into use in steel works for heating ingots. At present they are in operation at Crewe, Bolton, Barrow, the Mersey works, and some other places. They require a certain amount of care in their management, but yield very satisfactory results in their working. They are expensive in first cost, but in districts where coal slack is abundant they are exceedingly economical in respect of fuel, since they allow of the use of this cheap material instead of better and more expensive coal. But even where good coal must be employed in the gas producers, the utilization of all the heat produced by combustion renders the saving of fuel very considerable as compared with the ordinary reverberatory furnace. For steel an excessively high temperature, such as is required for some operations, and which alone the Siemens regenerators are able to give, is not necessary, and when much steam power is required it may be quite as economical to employ the waste heat from the furnaces for heating the boilers as to pass it through regenerators for the purpose of heating the incoming gases for the furnaces themselves. In such a case as much and more expensive fuel might be required for generating steam under independent boilers as would be saved at the furnaces by the use of the regenerators. In this connection may be noticed a plan that has been adopted at the Bolton works with good results, viz: the heating of boilers by gas drawn directly from the gas producers. This, of course, gives the same economy in respect of the use of slack as already referred to. Where sufficient steam is already obtained or is not required at all, the regenerative furnaces are of undoubted advantage. Mr. Webb, at Bolton, states that it is still an open question with him whether it is preferable to heat his boilers, as already mentioned, by gas, or to place them over furnaces fired in the ordinary way with coal.

The sawing, straightening, and punching of rails are conducted in general as in America, with the exception that a single saw, or a pair side by side, instead of two separated by the length of the rail, is used. The length of the rail is regulated by stops on the carriage, one end being sawed off and the rail then passed along on the friction-rollers in the carriage till it reaches the stop, when the other end is cut off. The use of a single saw, it is claimed, enables the cut to be made at the most suitable point, as indicated by the appearance of the end, and also gives greater facility in varying the length of the rail as required for different orders. At Barrow, the rollers in the saw carriage are driven by friction gearing from the saw engine, so that the rail is passed along automatically; the carriage is also drawn up to the saw by a number of racks and pinions at intervals along its length driven in a similar manner.

At some works severe tests are adopted for ascertaining the quality of rails, and until more accurate knowledge of the nature of the Bessemer ingots is obtained some such tests would appear to be very necessary. The usual method of procedure is to place a rail from each lot made from one mixing of metal on supports three feet apart, and let fall upon it midway between them a weight of one ton from heights varying from 10 to 30 feet, and observing the deflection produced. It is considered that good rails should not break under this test, though they may bend considerably where great height of fall is employed.

The use of steel-headed rails is a point of great importance, but one on which at present little that is conclusive can be said. They have been made to a considerable extent at the Crewe works of the London and Northwestern Railway Company for use on that line, and Mr. Webb (formerly of Crewe) has patents for forms and materials of piles for their production. One of the points which Mr. Webb claims is interposing a layer of puddle bar between the steel face and the fibrous iron, for the purpose of making a more gradual transition between the crystalline and fibrous metals, and thereby securing a more perfect union in the successive layers. The same thing has been done for many years in the United

States. In the Exposition specimens of steel-headed rails of French manufacture are shown, which have been struck on the top of the head with a steam hammer, cracking vertically through both steel and iron, and buckling up the web without any appearance of separation between the steel face and the iron beneath it. Although the specimen gives no evidence of being a selected one, (the line of the weld being plainly marked on the external surface,) yet it is clear that no such test can decide a question which can really only be properly solved by experience under the conditions of regular working. A sudden blow may be incompetent to produce effects which may follow prolonged and irregular hammering under the wheels of railway trains. While, therefore, steel-headed rails cannot be pronounced an absolute success, there is every reason for prosecuting the experiment, and reasonable grounds for anticipating a perfectly successful result.[1]

As the production of rails is at present the largest branch of the Bessemer steel manufacture, the disposition to be made of the crop ends becomes a question of immediate importance, and that to be made of the worn-out rails one of future moment. As the metal, when it contains any material proportion of carbon, is unreliable when welded, it is not so easy to decide to what use the large amount of ends sawed off from the rails shall be put. At present it must be admitted they are rather a drug in the market. When an iron that works hot in the converter is used, a certain quantity of these ends may be remelted in the vessel without injury to the steel. About four hundred weight per charge of five tons is considered admissible at the Dowlais works, the scrap being first heated to a red heat in a furnace placed near the vessel, and thrown into the latter before running in the molten iron. It is difficult, however to dispose of the whole amount in this way. As large a portion as possible is sold to the Sheffield crucible steel makers, who remelt them, and sell them at a greatly advanced price. At some works, again, they are rolled into small plates, and in this form they may be used for the manufacture of plough shares and other kindred objects; or in some cases they may be rolled and drawn into telegraph wire; it would be impossible, however, to make fine sizes of wire from them. If the difficulty of disposing of the steel scrap is to continue, it forms another argument in favor of steel-headed rails, since these, when worn out, would contain but little steel and could be readily piled and rerolled, the pile being so arranged as to bring the steel in the least vital parts of the rail in case its presence should lead to any unsoundness of the welding. It would appear, however, that an adequate market for old rails could be formed by rerolling them into the form of bars for machinery and other purposes, for which, by reason of their superior strength, they should be more valuable than wrought iron.

[1] Experiments made in the United States, after a trial of two years, have demonstrated that a perfectly sound weld of the steel to the iron can be secured in the head of the rail.

MANUFACTURE OF TIRES.

Next in importance to the manufacture of steel rails is that of tires for locomotive and railway carriage wheels. Four years ago it was attempted to weld these up, as in the case of iron from straight bars, but the unreliability of all tires so made was soon apparent, and the attention of manufacturers was directed to discovering some practicable means of producing them without welds. With the exception of the form of the ingot cast for the purpose, the mode of manufacture adopted at all the English works has attained a remarkable degree of uniformity. Mr. Ramsbottom casts his tire ingots in the form of a truncated cone, a usual size being two feet diameter at the bottom, six inches diameter at the top, and thirty inches height. This he hammers on its ends and sides till it assumes the shape of an ordinary flat cheese, with a thickness of about twelve inches. Another heat is then taken on it, and it is then placed under a steam hammer furnished with a pointed conical tool, and by successive blows with this on both sides a hole is forced through the centre of the disk, and this again expanded as the hammering proceeds, till the upper part of the tool, which is flat, comes down upon the tire and consolidates the metal by reducing its thickness. A third heat is then taken, and the ring so formed is placed over a stout beck projecting from the inclined side of an anvil, which maintains the ring in such a position as to give a suitable bevel to the outer face when struck by the hammer, while at the same time its diameter is considerably increased by the operation. After this third hammering it is ready for the rolls, and a fourth and last heat is taken for that purpose. Mr. Ramsbottom holds a patent for the method of punching the tire blocks by a sharp-pointed conical tool without the removal of any of the metal. The form of rolling mill employed by Mr. Ramsbottom is exceedingly complicated, and is the only one of its kind, as far as the writer is aware, which is in use in England, unless it be at the works of the patentee, Mr. Jackson, at Manchester.

At Mr. Allen's works, Sheffield, (H. Bessemer & Co.,) the cheese-shaped blocks are produced from an ingot of the ordinary square form, this being cast sufficiently large to form a number of tires, say four, and then hammered round and cut up into sections, each of a weight suitable for one tire. The central hole is punched by flat-ended punches about eight inches in diameter at the lower end, and perhaps nine inches above, driven in from both sides successively, and knocking out a circular disk about two inches thick as scrap. The blocks used with this process are of less thickness, say seven inches. The hole so formed is slightly enlarged by forcing the ring down over a truncated conical block which is placed on the anvil for the purpose, and subsequently another heat is taken, and the hammering continued on the inclined back of an anvil, as already described. The weight of the block can be accurately adjusted by varying the thickness at the time of punching out the central disk, by which means the amount of metal removed will be effected Another plan adopted by Mr. Allen is to cast annular ingots, sometime a number, one above the other, fed from one gate. These are cast witl considerable depth, so as to allow of sufficient hammering to thoroughly consolidate the metal, and the weight is regulated by the size of the cen tral core employed. For rolling the tires from the hammered rings h employs the tire-mill constructed by Messrs. Galloway & Sons, of Man chester, which is the simplest one in use, and gives results probably no at all inferior to those of other more complicated forms. It is the on most generally adopted in England. The only other variation in th tire-making process is, that at some works, for the purpose of avoidin the severe one-sided strain brought upon the hammer by the use of th inclined beck for bevelling the rings, the ring is placed on a stout man drel supported on a bifurcated anvil, and the necessary bevel is given by a tool of the proper shape with which the hammer is furnished. In Gal loway's and most other tire-rolling machines the roll spindles are place vertically and extend to a considerable distance below the horizontal be of the machine. The rolls themselves are situated just above the sur face of the latter, with no bearing above them, the spindles being lon and stiff enough to resist all the strain coming upon them. The tire i thus readily dropped over the ends of the rolls and removed when finished Its diameter is determined by a simple sliding gauge, measuring from the centre of the internal roll to the inner face of the tire at its greatest distance from the former. Bessemer steel tires by the above processe are now made in great numbers and give good satisfaction in use. Ther are some who still prefer the crucible steel for this purpose, but th difference in cost is so largely in favor of the Bessemer metal that it i probable the former will eventually cease to be made.

MANUFACTURE OF BESSEMER PLATES.

The application of the Bessemer process to the production of plate either for boilers or for ships, girders, &c., is one of the most importan that could be made. Nevertheless the amount of metal used for thi purpose in England falls much below that employed for other purposes This is due to a certain amount of distrust of steel plates, doubt as to its reliability under varying strains of tension and compression, its capa bility of being punched and sheared without injury to itself, and of its action under the influence of heat and water as in the fire-box of a boiler In other countries, as for example Austria, as will be shown when we come to speak of the manufacture as carried on in that country, this has not been the case, and large quantities of plates have been produced and successfully applied to a variety of uses.

The secret of the distrust in regard to Bessemer plates in England is that in nearly all cases the percentage of carbon contained in the meta has been too large. The spiegeleisen used in England is not particularl rich in manganese—seldom exceeding nine per cent. of that elemen while it generally contains from four to four and a half per cent. of carbon. It is difficult, therefore, with such materials to deoxygenate the metal sufficiently without introducing also a considerable percentage of carbon. About 0.4 per cent. of the latter is as large an amount as is proper for plates which are to resist severe strains, and though a greater proportion adds materially to the tensile strength of the metal when measured simply by a direct pull, it renders it also much harder and more liable to crack under the treatment to which it is exposed in the ordinary methods of construction. The difficulty in the way of producing good soft plates for boilers or other uses appeared at one time to have been satisfactorily overcome by the substitution of ferro-manganese in the place of the ordinary spiegeleisen. The manufacture of this substance was commenced by a firm in Glasgow as a branch of another business in which they were engaged, and plates made with it as a deoxygenator gave most excellent results. Unfortunately, however, the firm who had undertaken the manufacture shortly afterward became insolvent, and the patentee of the process has not as yet re-established the manufacture (which requires a considerable expenditure for suitable furnaces) elsewhere in England. Had the use of this substance continued for a longer time, so as to make the excellence of the steel produced with it fully appreciated by the public, there would have been a demand for plates urgent enough to have immediately secured the re-establishment of the manufacture; but in the present state of feeling it may not be so easy to induce the necessary primary outlay, especially as a certain amount of ill feeling is said to exist between the owners of the ferro-manganese patent and the Bessemer interest. The percentage of manganese contained in the alloy produced by the process referred to varied from 15 to 25. Another kind of ferro-manganese, containing a much larger percentage and produced in Germany by a different process, also the subject of a patent, has been offered in the English market, but at such an exorbitant price that nobody has ventured to buy it. Still, notwithstanding the absence of ferro-manganese, good soft plates are produced at some works, especially those at Bolton. Messrs. Charles Cammell & Co. also make a large number of plates of good quality. The following tests, which they guarantee all their plates to stand, are interesting.

Tensile strain per square inch, 33 tons.

Forge test, (hot.)—All plates one inch thick and under to bend hot without fracture to an angle of 180°, both lengthways of the grain and across.

Forge test, (cold.)—All plates will admit of bending cold without fracture as follows:

Bessemer plates.

	With the grain.	Across the grain.		With the grain.	Across the grain.
	°	°		°	°
1 inch	45	25	$\frac{7}{16}$ inch	90	70
$\frac{7}{8}$ inch	50	30	$\frac{3}{8}$ inch	110	80
$\frac{3}{4}$ inch	60	40	$\frac{5}{16}$ inch	120	90
$\frac{5}{8}$ inch	70	50	$\frac{1}{4}$ inch and upwards	120	100
$\frac{1}{2}$ inch	80	60			

To show the comparison of this steel with the regular crucible steel, the guarantee for plates of the latter is also given.

Crucible steel plates.

Tensile strain per square inch, 38 tons.

	With the grain.	Across the grain.		With the grain.	Across the grain.
	°	°		°	°
1 inch	50	30	$\frac{7}{16}$ inch	130	100
$\frac{7}{8}$ inch	60	35	$\frac{3}{8}$ inch	150	110
$\frac{3}{4}$ inch	75	50	$\frac{5}{16}$ inch	180	120
$\frac{5}{8}$ inch	90	70	$\frac{1}{4}$ inch and upwards	180	120
$\frac{1}{2}$ inch	110	90			

Probably the spiegeleisen used for this purpose is selected with especial care and may contain as much as eleven per cent. of manganese without an increased proportion of carbon. By a proper system of testing the ingots, as described above, there should be and is no difficulty in ascertaining just what percentage of carbon is contained in the metal, and so selecting ingots that are suitable for this purpose. With the superior franklinite that we possess, together with the purer irons, there is, apparently, no reason why we should not produce most excellent plates in large quantities, as is already done in Austria.

The manufacture of axles is carried on to a considerable extent, both for locomotives and railway carriages. Locomotive crank shafts are now more frequently made of this material than any other, and with a far greater exemption from breakages. These are usually forged from large rectangular ingots, and twisted to the proper angle as in the case of iron. To bring these large masses down properly with economy requires very heavy hammers, and to meet this want Mr. Ramsbottom has erected to Crewe a thirty-ton hammer, on his patent duplex principle. In order of dispense with the costly foundations necessary to sustain the impact at the falling tup in large hammers, Mr. Ramsbottom designed about five years since a hammer in which the blow should be struck by two heavy masses mounted on wheels, and moving horizontally in opposite direcitons, so that their momentum should be annihilated in striking the ingot placed between them. In the first of these hammers, in which the weight of each tup was ten tons, the cylinder was placed vertically in a pit beneath the hammer and the piston, connected by inclined links to each tup, so as to communicate motion to them on the rails. The ingot was supported on a suitable table, or between a pair of stout centres, which again rested on a platform capable of being rocked slightly to maintain the ingot always exactly in the centre of the motion of the tups. A number of these hammers are at present in use, and though they constitute the first development of a new idea, they do their work tolerably well, though they need a greater amount of care than an ordinary hammer. In the thirty-ton hammer which has been more recently built, the design has been somewhat modified, and greater simplicity obtained. In this the steam cylinders are horizontal, and placed directly behind each tup, the piston rods being secured to the latter by an elastic packing, so as to relieve the piston from the shock of the blow. To control the motion of the two tups, so that they shall always meet at the same point, a five-threaded screw with a diameter of six inches and a nine-inch pitch, or once and a half its diameter, is placed beneath them, the thread being cut left-handed at one end, and right-handed at the other. A nut secured to the bottom of each tup works on the portion of the screw beneath it, and as the screw revolves in its bearings each tup advances by the same amount. This arrangement is found to work with but little friction, and is not liable to derangement. The valve gear is made to be worked by hand in the ordinary way. The size of the cylinders and pressure of steam are so proportioned as to make the pressure on each tup the same as its weight, and the blow struck by this hammer is therefore the same as would be given by one of the tups falling by gravity through a distance equal to the combined stroke of the two tups, or seven feet. These hammers have been constructed by Messrs. Thwaites & Carbutt, of Bradford, who have had great experience in this line of business, having perhaps supplied more hammers to the steel-makers than any other firm. With the heavy hammers just described, the large ingots for crank axles are brought down to the required size and shape in a very short time. At Crewe it is usual to put two of these ingots into the Siemens furnaces in the evening, and allow them to heat slowly during the night, but one man being required to be in attendance, and then to work them off under the hammer in the morning before breakfast. In sawing off the ends of his finished axle forgings, Mr. Ramsbottom employs a saw seven feet six inches in diameter, running at about nine hundred revolutions per minute, or a speed on the edge of four miles per minute. The cheeks are also sawed out preparatory to turning the crank wrists.

In concluding the account of the Bessemer manufacture, as at present conducted in England, we may observe that while the amount produced is far in excess of that to be found elsewhere, yet from the close competition between the different makers tending to favor the use of the cheapest materials, and from the naturally rather inferior character of the native iron employed, the quality of the metal is not equal to that produced in countries using better materials. Accordingly the uses to which it has been chiefly devoted have been rails, tires, and axles, together with a certain amount of plates. Notwithstanding this there have been produced, when proper substances have been employed, specimens of the metal which seemed able to undergo almost any test that could be devised. It has been spun into ornamental vessels of shapes such as would bring the most severe strain on the metal without exhibiting any sign of cracking, or bent into the most crucial shapes, with equal evidence of its toughness. We shall see on examining the product of other countries that such qualities in the metal are not at all exceptional, but that when steel of great hardness is not intentionally produced, they always exist.

SWEDEN.

An examination of the specimens of Bessemer steel from Sweden in the Exposition shows us that the metal there produced is of a far superior character to that made in England, and naturally leads to inquiry as to the cause of the difference, and whether we may hope to attain the same success in the United States. First we observe coils of wire of all sizes, down to the very finest, such as No. 47, or even smaller. This they have not been able regularly to produce in England. In the next place we notice a good display of fine cutlery, and the writer is informed by a competent authority that this metal answers so well for this purpose that it is now used almost to the exclusion of any other. This statement is corroborated by the fact that in the miscellaneous classes of the Swedish department, where cutlery occurs not as an exhibition of steel, but merely as a display of workmanship by other parties in the same manner as other articles of merchandise, cases of razors are exhibited with the mark of the kind of steel of which they are made stamped or etched upon them as usual, and these are all "Bessemer," but from a variety of different works, viz: Högbo, Carlsdal, Österby & Söderfors. The ore used in Sweden for producing iron for the Bessemer process is exclusively magnetic, and of a very pure quality. An analysis of a mixture of those used for the iron employed at the Fagersta works before roasting gives the following composition:

Carb. acid	8.00
Silicium	17.35
Alumina	0.95
Lime	6.50
Magnesia	4.35
Protoxide of manganese	3.35
Magnetic oxide	32.15
Peroxide of iron	27.40
	100.05
Phosphoric acid	30

All the pig made from this mixture of ores the exhibitors state will give a steel without the use of spiegeleisen, which is not at all red short.

The analysis of gray iron from the same works, used for the Bessemer process, is given as follows:

Carbon combined	1.012
Graphite	3.527
Silicium	0.854
Manganese	1.919
Phosphorus	0.031
Sulphur	0.010

The cinder, produced at the same time as the gray iron, shows on analysis a composition of—

Silica	53.30
Alumina	3.00
Lime	21.10
Magnesia	13.95
Protoxide of manganese	7.85
Protoxide of iron	0.90
	100.10

The analysis of mottled pig, *(la fonte truité,)* consisting of two-thirds gray and one-third white, is—

Carbon combined	2.138
Graphite	2.733
Silicium	0.641
Manganese	2.926
Phosphorus	0.026
Sulphur	0.015

Of each of these it is stated that the steel produced without the employment of spiegeleisen is not at all red short, *(cassant à chaud.)* The most noticeable feature in the composition of these irons is the large percentage of manganese which they contain, together with the extremely minute proportion of sulphur. The latter quality is due to the exclusive employment of charcoal in the blast furnaces, together with the adoption of a very high temperature in the roasting kiln. These latter are constructed on Westman's patent, and are made very high and heated by the waste gas drawn from the blast furnaces. The heat is carried as high as is possible without agglomerating the materials, and by this treatment the ore is changed from a hard and compact substance to a very porous one, while at the same time it is stated that any percentage of sulphur less than four per cent. is driven off. The blast furnaces are very small, being generally but eight feet in diameter at the boshes and about three feet at the hearth, with a height of forty feet. With these ores prepared in this manner, such a furnace will yield from seventy to eighty tons per week. It is thought by the best informed engineers in Sweden that the furnaces should be made larger, and in future they probably will be s but these dimensions represent the furnaces that now exist, and wi which the iron in use has been produced.

In the process of conversion, from motives of economy, a fixed form vessel is employed, instead of one mounted on trunnions, as in Englan and elsewhere. The tuyeres, about nineteen in number, are placed hor zontally just above the bottom of the vessel, and are inclined a little fro a radial direction so as to give a rotary motion to the mass of molten meta An air passage surrounds the vessel at the back of the tuyeres, with movable plate opposite each to allow access to them. The upper portio of the vessel, from the line of the top of the blast passage, is made remova ble, for lining, &c.; the bottom of the vessel is slightly inclined toward the taphole, so that the whole of the metal and slag may run off. Th metal is run in at a spout in the upper portion of the vessel, and from th fixed position of the vessel it is of course necessary to have the blast o all the time that the metal is being run in and drawn off, to prevent it flowing into the tuyeres. This fact must make it more difficult to regu late the exact amount of decarbonization of the metal, and tend to rende the last portion drawn off overdone. The removal of the cinder remain ing in the vessel after a blow is not so easily accomplished in the fixe vessels as in the revolving one, as ordinarily used.

Accompanying the analysis of ores and irons, given above, the Fagerst works exhibit an analysis of the slag from the converter, taken at th close of the process, and it shows the composition to be as follows:

Silica	44.3
Alumina	10.8
Lime	0.6
Magnesia	0.4
Protoxide of manganese	24.5
Protoxide of iron	19.4
	100.2

The case of specimens exhibited by these works is the most interestin by far in the Exposition. It contains a most extensive collection of piece of various forms, with which a very elaborate set of experiments has ju been made at Mr. D. Kirkaldy's testing works at London, the result which will be found in Appendix D. The samples are classified accor ing to the percentage of carbon which they contain, and have been teste to show their action under strains of tension, compression, torsion, ben ing, and, in the case of plates, bulging.

The amount of carbon contained in the steel varies from 0.1 to 1.50 pe cent., though most of the experiments were made between the limits 0.3 and 1.20 per cent. In addition to the large collection of test pieces they exhibit some railway carriage axles containing 0.3 per cent. of carbon one being bent double with a radius of curvature at the bend of about inches; a locomotive axle containing 0.4 per cent., and a tire having 0.5 per cent. of carbon. There is, also, as already mentioned, a fine display of cutlery, razors, some beautiful hand mirrors containing 1.0 per cent., a small drill containing 1.50 per cent., with a plate beside it containing 1.00 per cent., through which it had drilled several holes; a number of long turnings taken off in a lathe, showing remarkably the absolute continuity of the grain—one of 0.3 per cent. of carbon measures 36 feet in length, and is closely coiled with a diameter of about $\frac{1}{12}$ inch; another of 0.9 per cent. is 27 feet long and slightly less in diameter. There are also a large number of files, and, as previously mentioned, coils of wire of all sizes, and apparently any required length. A very interesting table of results was obtained from a series of eleven small square bars containing varying percentages of carbon, as follows:

Strength of steel containing different amounts of carbon.

Number.	Per cent. of carbon.	Sectional area before elongation, square inches.	Breaking weight, in pounds.	Breaking weight, per square inch.	Section after fracture at point of rupture.	Proportion of ruptured section to original section.	Breaking weight per square inch of ruptured section.	Per cent. of elongation.
1	0.35	.2323	16,262	69,730	.0854	36.65	190,250	12.0
2	0.45	.1448	14,663	100,800	.0996	68.5	147,160	10.3
3	0.45	.1398	14,663	104,300	.1150	81.9	130,300	9.2
4	0.70	.234	29,540	125,800	.2026	86.3	145,750	1.56
5	0.70	.1568	16,074	102,300	.1314	83.46	122,300	4.0
6	0.70	.1515	19,841	131,400	.1400	92.05	141,660	5.4
7	0.70	.1485	17,016	114,100	.1230	82.55	138,240	5.8
8	0.90	.1466	19,935	135,400	.1189	80.80	167,500	6.7
9	1.00	.2338	30,012	128,000	.2242	95.69	133,800	2.3
10	1.00	.1516	20,218	132,700	.1400	91.93	144,300	6.6
11	1.00	.1494	21,726	144,800	.1400	93.31	155,120	4.0

The cost of steel for the more delicate uses, such as razors, &c., is very much less by the Bessemer process than by the old method of remelting in the crucible. The materials in ordinary use are sufficiently pure to give such a steel, and the only special precaution which has to be observed in producing these qualities is to add a sufficient amount of recarbonizing pig to give the required per cent. of carbon, and then in the process of tilting the bars to carefully reject any piece which may show sign of flaw, as would of course be necessary under any circumstances. The total production of Bessemer steel in Sweden in 1864 was 3,178 tons; that of crucible steel exceeded 4,500 tons.

AUSTRIA.

The conditions under which Bessemer metal is produced in Austria are in many respects similar to those existing in Sweden. The iron employed is smelted with charcoal, is nearly free from sulphur and phosphorus, and contains a large percentage of manganese. There are differences in the manner of conducting the process, but these important conditions insure the production of a metal of similar excellence to the Swedish, ε like this, much superior to the ordinary metal produced in England.

The principal works in Austria are at Neuberg, in the provinc Styria, and are carried on by the government. The iron is obtained f spathic ores smelted in two furnaces 43 feet high, and yielding from to 150 tons per week. The iron produced is found by analysis to con 3.46 per cent. of manganese, and, as in Sweden, it is used for recarl izing in the place of the usual spiegeleisen. Originally a fixed ve was erected at these works similar to those used in Sweden, but this been superseded by a pair of three-ton vessels of the ordinary const tion. Fixed or Swedish vessels are, however, still in use at other Aust works. The metal is run directly from the blast furnaces into the verters. Very interesting tables are exhibited by these works, giv analyses of the iron and slag at five periods in its conversion from condition as tapped from the furnace to its final state as Bessemer m These are extremely interesting from the light which they throw u the relative rapidity with which the components of the pig iron attacked by the blast, and the permanency of some ingredients, sucl phosphorus and copper, during the entire process. The results are follows:

Analyses of iron and slag during conversion to steel.

	As tapped from blast furnace.	After the disappearance of the sparks from the converter.	After the boiling over period.	End of blowing.	[illegible]
IRON.					
Graphite	3. 180				
Carbon combined	0. 750	2. 465	0. 949	0. 087	
Silicium	1. 960	0. 443	0. 112	0. 028	
Phosphorus	0. 040	0. 040	0. 045	0. 045	
Sulphur	0. 018	Trace.	Trace.	Trace.	T
Manganese	3. 460	1. 645	0. 429	0. 113	
Copper	0. 085	0. 091	0. 095	0. 120	
Iron	90. 507	95. 316	98. 370	99. 607	9
SLAG.					
Silica	40. 95	46. 78	51. 75	46. 75	
Alumina	8. 70	4. 65	2. 98	2. 80	
Protoxide of iron	0. 60	6. 78	5. 50	16. 86	
Protoxide of manganese	2. 18	37. 00	37. 90	32. 23	
Lime	30. 35	2. 98	1. 76	1. 19	
Magnesia	16. 32	1. 53	0. 45	0. 52	
Potash	0. 18	Trace.	Trace.	Trace.	T
Soda	0. 14	Trace.	Trace.	Trace.	T
Sulphur	0. 34	Trace.	Trace.	Trace.	T
Phosphorus	0. 01	0. 03	0. 02	0. 01	

From each charge blown at these works a small test ingot is cast, and is is immediately reheated and subjected to a number of tests to ascer- in the quality of the steel; and according to the results of these trials, the metal produced is divided into seven grades of varying hardness,). 1 being a blue steel, containing from 1.12 to 1.58 per cent. of carbon; d No. 7 a soft iron, with from 0.05 to 0.15 per cent.

The test employed consists in hammering the little ingot into a bar, d subjecting it to severe working on the anvil, in a way which would nd to crack it if of a red, short nature, or of inferior quality. It is then ated and plunged into water, and the amount of hardening produced oved by striking it with a hammer, and observing the amount of flex- e produced. It is then heated again and bent over upon itself and elded into an eye, the welded portion being drawn out to a small sec- on and broken off. These tests take but a short time, and the expense f making them is insignificant in comparison with the accurate know- dge thereby obtained of the nature of the steel and the purposes for hich it is suitable. As a rule, the steel produced at the Neuberg works elds with great facility, and, in fact, all the tires produced here are elded as in the case of iron. A table of the tensile strengths and other properties of steel, of the various classes below No. 2, is exhibited, and is as follows:

Tensile strength and other properties of steel.

	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
centage of combined carbon.	0.88 to 1.12	0.62 to 0.88	0.38 to 0.62	0.15 to 0.38	0.05 to 0.15
ile strength, tons, per square inch.	63.13 to 74.61	51.65 to 63.13	40.17 to 51.65	34.43 to 40.17	28.69 to 34.43
tensibility	0.05	0.10 to 0.05	0.20 to 0.10	0.25 to 0.30	0.30 to 0.25
rdening	With care	Very well	Very well	Feebly	Not at all.
lding	Very well, as hard cast steel.	Very well	Very well	Very well	Very well.

The softest grade is used for wire, sheet steel, &c., and the higher mbers for boiler plate, gun barrels, axles, tires, tools, and cutlery, cording to the hardness required.

A printed list gives the price of the steel in various forms delivered at e works, which, reduced to gold dollars, is as follows: ingots, $77 50; rs, $138; boiler plate, $145 50; tires, $155 50. These prices are little ove those charged in England, where coal is abundant and an inferior ality of metal produced.

PRUSSIA.

In other countries than Sweden and Austria, we find nothing that esents any remarkable feature not to be found in English practice. Of ourse, Krupp is far ahead of all others in respect to the size of the masses that he casts. He exhibits in the Exposition a 40-ton (40,000 kilograms) ingot, intended for a crank shaft, which he states was cast from crucibles. His process of making tires is similar to that in use in England. He first makes a bloom about 6 feet long and 13 inches by 10 inches, and then cuts this up into sections of the required weight. A slit is cut through the middle of these, and they are then worked out into an annular form, and afterwards rolled on a mill of a construction similar to those in use in England, with the exception that the bed, instead of being horizontal, is vertical, as if one of those machines were turned up on its edge. Two mills, one for roughing and one for finishing, are employed. His tire-heating furnaces are placed in a pit at the side of the mill, and are similar to the furnaces of a brass foundry, the tires being laid on the fire by a central crane.

FRANCE.

The French also exhibit good specimens of Bessemer metal, but, as already stated, there seems to be no marked advance on what has been accomplished in England, and it will not be necessary, therefore, to notice in detail the articles they have brought forward.

The manufacture has been established at six works, and the production, in 1866, was as follows:

	Tons
Compagnie de Terrenoire	1,537
Cie. de Chatillon, Commentry	5[illegible]
Societé d'Imphy, St. Seurin, (Jackson's)	4,85[illegible]
S. Menans & Cie	00[illegible]
De Dietrich & Cie	48[illegible]
Petin, Gaudet & Cie	3,851
Total	10,791

Of this product, 3,687 tons were in the form of rails. In 1863 but three works were in operation, with a total product of 1,857 tons. At the present time the metal produced in France by this process does not stand as high in the opinion of iron-masters as puddled or other steel. It may be that this is due to the nature of the pig iron employed, or it may be due to a lack of experience in the manufacture as compared with other nations.

At the works of Messrs. Petin, Gaudet & Co., near St. Etienne, a pair of six-ton converters have been erected, and a single vessel, capable at present of producing a charge of eight tons, and in which it is expected to make twelve-ton charges when the lining becomes reduced in thickness. This is the largest Bessemer apparatus in France.

Submitted by

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PARIS, *June* 15, 1867.

APPENDIX A.—*Table showing the analyses of the most important ores and iron of Sweden.*

The specimens for analysis represent usually the mass of the ore. If a small number of unroasted pieces have been taken the mark † is affixed; ‡ signifies roasted; * unroasted.

Name of the mine.	Year of working.	Name of chemist.	Percentages of constituents.						Percentages of constituents of earthy matters.						Oxygen of silicic acid and alumina divided by oxygen of the bases.	Quantity of carbonate of lime or of quartz for the fusion in per cent. of the ore.
			Iron.	Oxide of iron.	Earthy matter.	Phosphorus.	Sulphur.	Other matter.	Silica.	Alumina.	Lime.	Magnesia.	Manganese.			
PROVINCE OF NORRBOTTEN.																
Gellivare:																
Fredrika*	1862	L. Rinman	66.8	92.3	7.7	0.019	0	....	75.5	2.1	11.5	22.9	Trace	....	37.7-72.5=2.7	
Hertigen af Upland*	1862	......do	66.7	92.1	7.9	0.74	0	....	37.5	12.5	37.5	12.5	....	....	25.4-15.7=1.6	
Robsahm*	1862	......do	63.6	87.8	12.2	0.038	0	....	50.0	8.8	20.2	21.0	....	....	30.1-14.1=2.1	
Tingvallskulle*	1862	......do	65.7	90.7	9.3	0.512	0	....	44.3	12.2	33.5	8.6	....	Be: 1.4	28.7-13.7=2.1	
Törefors et Gyljen*	1862	......do	68.1	94.0	6.0	0.02	0	....	55.2	14.6	7.8	22.4	....	....	35.6-11.2=3.2	
Välkomma*	1862	......do	64.0	88.4	11.6	0.394	0	....	62.7	2.7	28.0	6.6	....	....	33.9-10.7=3.2	
Routivare*	1862	......do	54.2	74.9	25.1	0.004	Trace	....	12.4	25.2	5.4	18.3	1.9	Be: 1.3; Ti: 35.5	18.2-21.4=0.8	
Lousavare*	1861	......do	71.3	98.5	1.5	0.105	0	....	50.0	16.0	1.0	5.2	0.4	Ti: 17.2; Be: 9.2	....	
PROVINCE OF GEFLEBORG.																
Thorsaker:																
Nyäng*	1860	O. Troili	47.50	....	....	0.002	(0.09)a	....	....	....	....	....	....	....	....	5 p. ct. of lime.
Strand*	1860	......do	48.8	....	....	Trace	(0.09)	....	....	....	....	....	....	....	....	5 p. ct. of lime.
Erik Ers*	1863	L. Rinman	56.4	77.8	18.8	0.008	Cu. 0.3	C: 3.40	32.2	5.2	29.5	13.3	19.8	....	19.2-18.2=1.05	
Afze*	1863	H. Limnelius	18.8	26.0	52.0	0.01	0.06	C: 22.0	15.7	8.1	59.0	6.4	10.8	....	12.0-21.9=0.6	
Penning*	1863	G. L. Wetterdal	46.1	63.7	36.3	0.002	(0.04)	....	22.3	3.7	16.0	9.4	48.6	....	13.3-19.3=0.7	
Gymas‡	1859	D. A. Kruhs	36.1	49.9	50.1	0.061	(0.10)	....	83.5	4.6	7.9	3.3	0.7	....	45.6-3.7=12.3	
PROVINCE OF UPSALA.																
Dannemora:																
A mixture of 4 of the middle field in 1 of the north field‡	1859	Cl. Ullgren	50.7	69.2	30.8	0.005	0.07	Cu. 0.2	45.0	1.0	26.5	21.3	6.2	....	23.8-17.5=1.4	
of the south field‡	1859	......do	52.3	71.7	28.3	0.008	0.138	Cu. 0.16	48.3	1.4	20.8	20.8	8.7	....	25.7-16.2=1.6	

Table showing the analyses of the most important ores and iron of Sweden—Continued.

Name of the mine.	Year of working.	Name of chemist.	Percentages of constituents. Iron.	Oxide of iron.	Earthy matter.	Phosphorus.	Sulphur.	Other matter.	Percentages of constituents of earthy matters. Silica.	Alumina.	Lime.	Magnesia.	Manganese.		Oxygen of silicic acid and alumina divided by oxygen of the bases.	Quantity of carbonate of lime or of quartz for the fusion in per cent. of the ore.
PROVINCE OF UPSALA—Cont'd.																
Dannemora:																
Norra Kungs*	1865	B. Feruqvist	51.2	70.7	21.7	0.0026	0.08	C: 7.6	30.3	3.0	27.4	30.0	9.3		17.1-21.3=0.8	
Jord*	1865	do	56.1	77.4	18.0	0.0026	0.033	C: 4.6	33.3	2.9	23.0	31.6	9.2		19.0-21.0=0.9	
Södra Silfberg*	1865	do	62.1	85.8	11.7	0.0033	0.013	C: 2.5	35.2	6.5	23.5	21.7	13.0		21.3-18.3=1.1	
Lena: Sahlsta*	1863	L. Rinman	58.1	80.2	19.8	0.015	0.05	C: trace	68.8	9.1	9.1	12.2	0.8		40.1-7.7=5.2	
PROVINCE OF STOCKHOLM.																
Wahlö: Wigelsbo‡	1862	S. Sjöberg	51.3	70.9	29.1	(0.01)	(0.04)	Cu.(0.13)	59.6	1.9	19.0	19.2	0.3		31.9-13.2=2.4	
Börstil: Raggazö†	1861	J. O. Björck	49.7			(0.026)	(0.03)									
Sand‡	1861	R. v. Stockenström	55.1	76.1	23.9	(0.026)	(0.03)	Cu.(0.052)	55.7	9.3	27.0	7.2	0.8		23.2-10.7=2.2	
Häfverö: Herräng*	1863	J. F. Lunberg	50.0			(0.014)	(0.04)	Mn. 0.28								15 p. ct. of qtz.
Do‡	1863	L. Hallgren	57.9	80.0	20.0	(0.025)	(0.03)		36.0	3.9	46.5	12.7	0.9		20.5-18.5=1.1	
Broby*	1864	S. Cleophas	50.1	69.2	30.8	(0.01)	(0.3)		46.3	7.9	12.7	31.3	1.8		27.7-16.5=1.7	
Utrö‡	1862	J. A. Kullström	88.0	52.5	47.5	(0.165)	(0.04)	Cu. (0.06)	87.1	4.2	4.0	3.8	1.4		47.3-2.8=16.9	
Do*	1863	J. F. Lunberg	45.5			(0.17)	(0.03)	Mn. 0.47								20 p.ct. of lime.
PROVINCE OF STORA-KOPPARBERG.																
Leksand: Sörskog*	1859	C. Wahlund	43.4	59.9	40.1	0.005	(0.05)		63.4	5.1	23.1	5.4	3.0		35.3-9.5=3.7	
Qvarnback†	1861	A. R. Toren	52.5			0.04)	(0.03)									10 p.ct. of lime.
Abl: Blackberg‡	1858	F. Lindsback	43.2	59.7	40.3	(0.042)	(0.02)		59.3	4.5	30.3	4.9	1.0		33.0-10.9=3.0	

[illegible]jo-grufva*	1864	A. Andersson	45.2 55.0	[illegible]	[illegible]	Trace	(0.04)	....	58.2	8.8	23.8	8.1	1.1	....	34.4-10.2=3.4	
Harmsarf‡	1860	A. Carlson	55.9	77.2	22.8	0.026	....	....	....	....	....	....	....	....	....	10 p. ct. of qtz.
Skumaräng*	1863	J. F. Lundberg	49.0	....	....	(0.02)	(0.04)	Mn. 14.3	65.0	7.8	23.8	2.2	1.2	....	37.4-7.9=4.7	
Tuna: Hästberg‡	1856	C. A. Jacobosson	50.	69.8	30.2	0.02	0.04	....								
Örns-gr	1864	J. F. Lundberg	62.0	....	....	(0.014)	(0.02)	....	....		....	....	....	....	....	10 p.ct.of lime, & 10 p.ct.qtz.
Säther: Bispberg*	1837 1860	A. Erdmann O. Troili	64.4	88.9	11.1	0.005	(0.05)	....	47.9	5.2	8.8	10.5	27.6	....	27.4-12.9=2.1	
Engelsfors†	1859	G. Hjort af Ornäs	55.3	....	....	0.025	(0.02)	....	....		....	....	....	....	....	10 p.ct.of lime.
Rällingsberg‡	1859	L'Ecole des mines	61.0	84.2	15.8	(0.017)	(0.02)	....	49.1	9.8	23.5	15.0	2.6	....	30.1-13.1=2.3	
Garpenberg: Langvik‡	1861	J. F. Lundberg	43.6	60.2	39.8	(0.02)	(0.02)	....	18.5	2.3	40.6	16.5	22.1	....	10.7-23.2=0.5	
Holm‡	1861	......do	47.4	65.5	34.5	(0.02)	(0.05)	....	37.1	1.9	22.6	15.3	23.1	....	20.2-17.8=1.1	
Axberg*	1858	....	47.9	66.1	32.7	0.013	0.18	C: 1.2	61.6	8.0	23.7	5.8	0.9	....	35.7-9.3=3.8	
Hag‡	1858	J. F. Lundberg	41.0			0.14	(0.10)	....	....		....	....	....	....	....	
Folkärna: Knutsbo‡	1861	......do	45.5	62.8	37.2	(0.02)	(0.03)	....	76.6	2.4	7.8	9.4	3.8	....	41.0-6.9=6.0	
By: Westersjör†	1859	W. Tamm	41.5	57.3	42.7	Trace	(0.04)	....	55.7	2.3	30.2	11.0	0.8	....	30.0-13.2=2.3	
Vestra Ormberg Lilla Pick-grufva*	1861	L. Rinman	67.6	96.6	3.4	0.065	(0.025)	....	59.4	19.8	7.9	5.0	....	Ce: &c. 7.90	40.1-5.8=6.0	
Abrahams*	1861	......do	60.9	84.1	15.9	1.27	(0.015)	....	62.1	9.4	20.5	8.0	......	Ce: trace	36.7-9.1=4.0	
Kittel*	1861	......do	57.3	81.9	18.1	0.129	(0.03)	....	60.8	22.9	3.3	3.9	......	Ce: 9.1	42.3-4.3=9.7	
Grängesberg:																
Bredsjöbrott*	1861	......do	65.	89.9	10.1	0.502	(0.04)	....	39.2	22.	14.1	24.6	......	Ce:	30.7-13.8=2.2	
Galthafvud*	1861	......do	59.0	85.6	14.4	0.132	(0.035)	....	80.7	10.3	4.2	4.8	......	Trace.	46.8-3.1=15.1	
Enkulle*	1861	......do	57.7	82.5	17.5	0.101	(0.02)	....	77.8	11.7	3.2	7.3	Trace	....	45.9-3.9=11.9	
Godgrufva‡	1862	R. Kullberg	57	79.6	20.4	0.04	(0.02)	....	75.8	12.4	5.7	4.8	1.3	....	45.2-3.8=11.7	
Fäboback‡	1860	J. F. Lundberg	38.	....	....	(0.05)	....	....	....		....	....	....	....	....	8 p. ct. of qtz.
Ludvika:																
Främmundberg Tägst†	1862	......do	52.4	72.4	27.6	(0.05)	(0.04)	....	47.8	23.4	8.2	18.7	1.9	....	35.8-10.2=3.5	
Fumäs‡	1859	G. Hjort af Ornäs	47.4	....	....	(0.07)	(0.31)	....	....		....	....	....	....	....	15 p.ct.of lime.
Jolke:																
Lejon*	1860	C. H. Lundström	53.2	73.4	26.6	0.034	0.09	....	73.4	8.8	4.3	11.8	1.7	....	42.2-6.3=6.7	
Folke:																
Laug‡	1861	J. N. Björlingson	45.	62.6	37.4	0.04	(0.03)	....	77.2	10.0	8.9	1.5	2.4	....	44.8-3.6=12.3	
Haksberg*	1861	C. G. Ekman	47.	....	....	(0.20)	(0.03)	....	....		....	....	....	....	....	20 p.ct.of lime.
Gräsberg‡	1861	J. N. Björlingson	51.	....	....	0.03	(0.02)	....	....		....	....	....	....	....	10 p.ct.of lime.
Do‡	1859	C. W. Rinman	44.	62.0	38.0	0.043	(0.02)	....	83.1	6.0	2.7	7.8	0.9	....	46.1-3.9=11.8	
Norrberke:																
Östanberg Smed.*	1861	E. Rinman	46.	64.2	35.8	3.01	0.06	....	71.0	7.4	14.2	7.4			40.4-7.0=5.8	
Östanberg Tun et Lang*	1859	G. Hjort af Ornäs	42.	....	....	Trace.	(0.7)	....	....		....	....	....	....	....	10 p.ct.of lime.
Hemgrufva*	1860	A. B. Littorin	42.8	....	....	(0.01)	(0.64)	....	....		....	....	....	....	....	5 p. ct. of lime.

Table showing the analyses of the most important ores and iron of Sweden—Continued.

Name of the mine.	Year of working.	Name of chemist.	Percentages of constituents.						Percentages of constituents of earthy matters.					Oxygen of silicic acid and alumina divided by oxygen of the bases.	Quantity of carbonate of lime or of quartz for the fusion in per cent. of the ore.
			Iron.	Oxide of iron.	Earthy matter.	Phosphorus.	Sulphur.	Other matter.	Silica.	Alumina.	Lime.	Magnesia.	Manganese.		
PROVINCE OF WESTERAS.															
Norberg:															
Risberg—Föreumgs*	1863	T. W. Fagerholm	54.3	74.9	25.1	(0.05)	(0.03)	....	92.3	2.7	1.6	1.8	1.6	49.3-1.6=31.8	
Pantzar*	1861	L. Rinman	49.1	70.2	29.8	0.022	0.005	....	75.9	1.0	19.4	3.7	0	40.-7=5.7	
Örling‡	1861	J. P. Lundberg	49.0	67.7	32.3	(0.03)	(0.05)	....	81.1	3.2	9.8	5.1	0.8	43.7-5.1=8.6	
Svartberg*	1863	H. Klint	48.1	66.5	33.5	(0.09)	(0.03)	....	89.4	4.5	2.7	2.4	1.0	48.0-2.3=21.3	
Lilla Ny*	1864	P. Edman	31.7	43.8	56.2	(0.02)	(0.03)	....	56.5	8.5	22.5	12.5	....	33.4-11.5=2.9	
Hülphers	1864	A. Westerberg	48.9	67.5	32.5	(0.05)	(0.03)	....	89.0	4.5	0.2	5.1	1.2	48.4-2.4=20.1	
Flik*	1859	A. F. Groth	48.7	67.3	32.7	0.016	(0.01)	....	87.9	Trace	7.2	0.8	4.1	45.7-3.4=13.9	
Graurot*	1861	L. Rinman	51.7	71.4	17.4	Trace	0	C: 11.2	21.6	0	21.0	18.8	38.6	11.2-22.2=0.5	
Gröndal*	1863	E. Dufva	60.5	83.6	16.4	(0.01)	(0.02)	....	35.1	6.7	17.6	13.7	26.9	22.4-16.6=1.4	
Spetals*	1864	B. Fernqvist	49.9	71.4	28.6	0.003	0.006	....	89.5	1.7	7.9	0.4	0.5	47.3-2.5=18.8	
Näsberg*	1864	......do	30.1	41.7	38.2	0.018	0.23	C: 20.1	23.6	1.0	60.1	11.9	3.4	12.7-22.5=0.6	
Skinskatteberg:															
Bastnäs: (Riddarhytta)‡	1859	J. F. Lundberg	45.6	65.1	34.9	0.009	(0.02)	....	87.1	4.1	4.3	4.5	Trace	47.2-3.0=15.7	
Sala: Springar‡	1857	......do	50.2	69.3	27.6	0.012	0.075	C: 3.10	60.1	12.0	20.6	4.7	2.6	36.9-8.4=4.4	
PROVINCE OF ÖREBRO.															
Nya Kopparberg:															
Lomberg: Storbatten*	1863	C. H. Lundström	49.9	71.3	28.7	0.076	0.04	....	85.4	8.4	3.9	2.0	0.3	48.3-2.0=24.2	
Svartvik*	1863	......do	48.0	66.3	26.9	0.01	0.05	C: 6.8	36.3	7.8	28.9	17.0	10.0	22.5-17.5=1.3	
Do*	1862	L. Rinman	53.2	73.6	21.0	Trace.	0.043	C: 5.4	39.1	4.6	19.4	19.7	17.2	22.5-13.7=1.6	
Ramsberg: Blanka	1860	......do	......	......	......	0.014	......	....	......	......	......	......	....	....	
Strassa*	1862	......do	48.9	67.5	32.5	0.004	0.11	....	85.9	7.1	1.8	3.2	2.0	48.0-2.3=21.3	
Linde: Gränsbytte Moss*	1862	......do	55.7	77.0	23.0	0.011	Trace.	....	90.8	4.0	3.0	2.2	Trace	49.0-1.7=28.0	
Stripa*	1862	......do	59.0	82.9	17.1	0.005	Trace.	....	78.9	2.8	8.9	9.4	Trace	42.35-6.3=6.7	
Fanthytte: Johannisberg*	1854	J. F. Baer	44.0	60.8	35.8	0.019	0.85	C: 3.4	52.4	3.6	14.3	26.0	3.7	28.9-15.3=1.9	

[illegible]		[illegible]	41.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.8	8.9	9.4	Trace		[illegible]
Limnäs Hag*	1862	L. Rinman	[illegible]	42.7	34.6	0.015	0.13	C: 22.7	13.3	8.5	[illegible]	33.4	10.0	....	[illegible] 5-26.0=0.4
Hellefors: Björnhöjde*	1859	C. H. Lundström	50.1	69.1	30.9	0.20	0.06	....	50.9	11.5	23.	12.3	1.9	....	31.3-12.0=2.6
Smalkärn*	1863	......do	63.6	87.9	12.	0.012	0.04	....	60.	12.0	17.	5.0	4.8	....	36.9-8.2=4.5
Grythytte: Högborn*	1862	L. Rinman	58.	80.2	19.	Trace.	0.01	....	54.4	9.1	21.7	18.3	0.5	....	30.5-13.6=2.2
Nora: Dalkarlsberg—															
Flint‡	1856	......do	62.8	86.7	13.3	0.19	0	....	44	19.4	12.0	23.9	0	....	32.2-13.0=2.5
Herr*	1859	C. L. Rinman	64.	88.6	11.	0.057	0	....	46.3	21.8	12.2	17.5	2.2	....	34.2-11.1=3.2
Kettil*	1859	......do	61.5	84.9	15.	0.083	0	....	49.5	17.1	11.5	20.2	1.7	....	33.7-11.7=2.9
Österry ming*	1859	......do	62.2	84.6	15.	0.05	0.03	....	45.9	30.8	7.9	13.3	2.1	....	38.2-8.1=4.7
Fall No. 1	1859	J. F. Lundberg	67.8	....	....	(0.043)	(0.02)	....	....	....		......	......	....	....
Wiker*	1861	L. Rinman	41.	56.4	32.	0.023	0.40	C: 11.5	41.5	7.1	7.4	29.6	14.4	....	24.9-16.8=1.5
Asboberg*	1866	C. H. Lundström	60.	86.8	13.	0.019	0.05	....	60.6	19.4	10.5	9.1	0.4	....	41.4-6.7=6.2
Striberg*	1866	C. H. Lundström	50.0	71.4	28.6	0.016	0.04	....	91.5	1.4	5.5	1.1	0.5	....	49.4-2.1=23.5
Svartberg*	1866	......do	57	79.8	21.2	0.007	0.045	....	73.5	5.6	8.0	10.7	2.2	....	41.8-7.0=6.0
Klacka and Lerberg*	1863	L. Rinman	60.	83.9	11.	0.002	0	....	75.6	8.5	5.1	9.7	1.1	....	43.3-5.6=7.7
Hoilarc: mo*	1862	B. Ferngoirt	68.4	94.5	5.5	Trace.	0.05	C: 0.02	55.2	17.2	7.8	19.0	0.8	....	36.7-9.8=3.7
PROVINCE OF CARLSTAD.															
Filipstad: Nordmark*	1862	C. H. Lundström	55.	77.1	22.9	0.02	0.025	....	55.0	4.7	20.5	16.6	3.2	....	30.7-13.2=2.3
Brattfors*	1863	L. Rinman	59.8	82.6	16.8	Trace.	0.012	C: 0.6	56.7	4.1	22.8	13.4	3.0	....	31.4-12.5=2.5
Taberg l*	1863	......do	53.4	73.8	25.5	0.013	0.05	C: 0.7	59.5	5.6	11.2	23.1	0.6	....	33.5-12.5=2.7
Taberg st.*	1863	......do	56.	77.7	21.2	0.013	0.05	C: 1.1	57.4	7.2	10.5	23.7	1.2	....	33.2-12.7=2.5
Eng*	1862	......do	56.	78.2	20.6	0.012	0.03	C: 1.2	46.8	6.1	26.3	17.6	3.2	....	27.2-15.3=1.8
Age*	1856	Cl. Ullgren	51.2	70.7	29.3	0.028	0.21	....	54.5	4.5	17.	20.5	3.4	....	30.4-13.8=2.2
Tersberg: Stor*	1856	L. Svanberg	53.3	73.4	26.6	0.003	0.03	....	57.1	11.2	11.9	19.6	0.2	....	35.7-11.2=3.2
Kran*	1856	......do	50.3	69.2	30.8	0.008	0.03	....	57.1	9.5	14.2	18.1	0.1	....	35.4-11.3=3.1
Gustaf Adolf*	1865	C. H. Lundström	53.3	73.4	26.6	0.008	0.035	....	51.0	5.0	21.0	22.3	0.7	....	25-15=1.7
Ö. Hagen*	1865	......do	57.1	78.6	21.4	0.007	0.03	....	62.7	5.5	13.6	17.7	0.5	....	35.1-11.1=3.2
Jordaskär*	1863	L. Rinman	59.9	82.7	16.8	0.002	0.016	C: 0.5	55.0	6.0	24.3	12.1	2.6	....	32.0-12.1=2.6
Langban	1862	......do	62.6	89.4	10.6	0.017	0.024	....	80.8	5.4	5.9	7.9	Trace	....	45.6-4.8=9.5
Fagerberg*	1862	C. H. Lundström	50.1	69.1	30.9	0.01	0.33	Cu. 0.12	45.3	8.6	32.8	6.2	7.1	....	27.6-13.4=2.1
PROVINCE OF NYKÖPING.															
Staf‡	1859	L. A. v. Celsing	40.1	55.4	45.6	0.05	....	....	78.3	6.1	6.8	5.9	2.9	....	43.6-4.9=8.8
Skalnirda—Wilhelmina*	1859	C. Wahlund	58.0	80.2	19.8	0.072	(0.03)	....	49.0	38.2	9.5	Trace	1.8	Ti: 1.5	43.2-3.7=11.7
Elgsjö‡	1862	J. O. Källgren	50.2	69.3	30.7	(0.04)	(0.03)	Cu. trace	84.5	4.0	4.8	4.2	2.5	....	45.8-3.6=12.7
Förola‡	1858	C. D. Tideström	55.7	76.9	23.1	0.01	(0.06)	....	90.7	4.1	2.6	0.4	2.2	....	49.1-1.4=35.0

Table showing the analyses of the most important ores and iron of Sweden—Continued.

Name of the mine.	Year of working.	Name of chemist.	Percentages of constituents.						Percentages of constituents of earthy matters.						Oxygen of silicic acid and alumina divided by oxygen of the bases.	Quantity of carbonate of lime or of quartz for the fusion in per cent. of the ore.
			Iron.	Oxide of iron.	Earthy matter.	Phosphorus.	Sulphur.	Other matter.	Silica.	Alumina.	Lime.	Magnesia.	Manganese.			
PROVINCE OF ÖSTERGÖTLAND.																
Natorp*	1860	A. F. Groth	47.1	65.1	34.9	0.016	(0.07)	....	57.5	2.8	32.1	7.1	0.5	....	31.2-12.1=2.6	
Petäng‡	1858	J. A. M. Siberg	46.7	64.6	35.4	0.01	(0.1)	....	55.5	11.2	18.9	12.8	1.6	....	34.1-10.8=3.1	
Stenebo‡	1858	M. B,o kman	57.9	80.0	20.0	0.03	(0.09)	....	80.4	9.6	3.2	5.2	1.	....	46.2-3.3=13.8	
PROVINCE OF JÖNKÖPING.																
Taberg‡	1864	B. Fernqvist	31.2	43.4	54.0	0.056	0.013	Bitumen and H. 2.6	39.8	10.4	3.1	34.2	0.7b	Ti: 11.	28.1-14.3=2.0	
PROVINCE OF KRONOBERG.																
Langhutt	1865	B. Fernqvist	41.1	56.7	43.3	Trace	....	....	47.1	18.5	1.9	11.6	0.5	Ti: 20.4	....	

a The parenthesis signifies that the analysis for the per cent. of sulphur or phosphorus is made with the regulus of cast-iron, obtained in the small crucible of Sefström's furnace.
b Other specimens contain more manganese.

APPENDIX B.

TABLE SHOWING SEVERAL MARKS OF SWEDISH IRONS.

Mark.	Name of works.	Post Office.	Annual production in ons.	Principal ores.
	PROVINCE OF NORRBOTTEN.			
S: B:	Gellivore	Råneå	300	Gellivare.
	PROVINCE OF WESTERBOTTEN.			
HR RH	Hörnefors	Umnea	1,100	From middle of Sweden.
ICP	Olofsfors	Nordmaling	300	Id.
RI AB	Robertsfors	Ånäsen	600	Id.
FSL	Säfvare	Umnea	180	
	PROVINCE OF WESTER NORRLAND.			
CNF	Björkå	Nyland	150	From Lenaberg, Norberg, and Utö.
[illegible]	Forsse	Nyland	1,400	Id.
[illegible]	Graninge			
[illegible]	Sollefteå			
×GB×	Galtström	Sundsvall	380	From Utö, Bispberg, etc.
I G	Gideå	Örnsköldsvik	350	
ER	Gåhlsjö	Nyland	170	From Lenaberg, Norberg and Utö.
Ö Lö	Lögdö	Sundswall	175	From Stochenström, Utö, etc.
MF PD	Matfors	Id.	200	
[illegible]	Norafors	Id.	175	From Staf.
CH B NG	Sörfors, etc.	Id.	600	From Roslag.
TH	Torpshammar	Id.	230	
L	Westtanå	Hernösand	340	
LP	Åviken	Sundswall	130	

Mark.	Name of works.	Post Office.	Annual production in tons.	Principal ores.
	Kloten and Granhult	Köping or Ramsberg	980	From Grängesberg, berg, and Ramsbe
	Korså and Svartnäs	Falun	1,600	From Vintjern and naräng.
	Larsbo	Smedjebacken	600	From Ostanberg, No
	Limå and Noraå	Gagnef / Falun	920	From Tuna Hästbe
	Lindesnaes	Gagnef	1,500	From Gräsberg.
	Snöå		900	From Sommarberg.
	Ludvika	Smedjebocken	1,600	From Ivike, Främ berg, Finnås and berg.
	Långö	Mora	270	
	Malingsbo	Wik	510	From Grängesberg,
	Norn	Hedemora	280	From Bipsberg.
	Norså and Olofsfors	Smedjebocken	230	
	Nyhammar	Id	1,600	From Grängesberg Ivike.
	Siljansfors	Mora	280	From Sörskog, etc.
	Stjernsund	Hedemora	280	From Bispberg and berg.
	Thurbo and Wikmanshyttan (Cast steel.)	Hedemora	760	From Bispberg and berg
	PROVINCE OF WESTERÅS.			
	Baggå	Köping	470	From Gräsberg and berg.
	Berntshammar	Id	410	
	Bjurfors	Norberg	270	From Norberg.
	Engelsberg	Id	320	Id.
	Fagersta	Id	1,200	Id.
	Ferna	Köping	1,700	From Gräsberg, Ny and Grängesberg.

Mark.	Name of works.	Post Office.	Annual production in tons.	Principal ores.
BR HH KH	Gislarbo	Köping	900	From Riddarhytta.
CN	Hallstahammar	Strömsholm	450	
HP PB	Högfors and Persbo	Norberg	250	From Norberg.
N	Jäder	Arboga	280	
SP GS GH	Karmansbo, etc	Köping	1,300	From Norberg and Grängesberg.
VH BC LC LL	Kolsva	Köping	1,200	From Stripa, etc
RB	Ramnäs	Westerås	940	From Östanberg, etc.
IA	Seglingsberg	Id.	430	From Norberg.
VR	Skattmansö	Enköping	260	
SG	Skinnskatteberg	Köping	680	From Billsjö and Norberg.
Sh	Surahammar	Westerås	1,400	From Norberg.
BK SVANÅ	Svanå	Id.	760	Id.
T	Trångfors	Strömsholm	190	
IW	Uttersberg	Köping	340	From Gräsberg, Tyskgrafva, etc.
HH	Westanfors	Norberg	190	From Norberg.
	Wirsbo	Westerås	430	
	PROVINCE OF ÖREBRO.			
GK GK	Aspa	Askersund	490	From Nora.
BF BFC PPS	Bofors	Carlskoga	1,000	From Persberg and Nora.
	Bohr	Lindesberg	160	From Lomberg, etc.
	Bredsjö	Nora	170	From Ösjöberg, Gröndal, etc.
GR	Brefven	Kilsmo W. S. B.	350	From Nora and Lanna.
FCK	Bångsmedjan	Nya Kopparberg	140	From Lomberg, etc.

Mark.	Name of works.	Post Office.	Annual production in tons.	Principal o
K	Degerfors Ö	Åtorp	150	From Dalkarlsl Striberg.
WC H	Degerfors N	Begerfors N. W. S. B.	850	From Persberg, berg, Striberg
K	Elfstorp	Nora	720	From Högborn.
PF	Frötuna	Arboga	390	
GD, G, W, D, R (Common marks.)	Gammelbo (Company of Gammelbo.)	Ramsberg	270	From Ramsl Pershytta.
	Finnåker	Arboga	1,050	
	Grönbo	Id	220	
	Ramshytta	Nora	120	
GB	Garphyttan	Örebro	260	From Pershytta grafva, etc.
HH AH	Gryn	Pålsboda W. S. B.	1,020	From Nora.
V	Haddebo Ö	Id	210	Id.
PW BS	Haddebo N	Id	290	Id.
	Hammarby	Nora	1,000	From Hagby, etc.
MF W	Hasselfors	Hasselfors N. W. S. B.	600	From Dalkarlsb berg and Vike
HS LS1 H C	Hellefors	Grythyttehed	2,810	From Lomberg ε vik, etc.
NE	Högfors	Nya Kopparberg	120	Id.
S×L LS	Lassåna	Laxå W. S. B.	430	From Nora.
HSH	Laxå	Id	850	From Dalkarlsb berg, and Vik(
	Petersfors	Nora	150	From Jernboås.
	Ramsberg	Ramsberg	150	From Stråssa an
PV	Ramshytta	Id	140	Id.
K·	Rockesholm	Nora	260	From Skärhytta born.
DSR	Rockhammar	Arboga	1,050	From Stripa, Mo etc.
	Sikfors	Grythyttehed	150	From Finnberg,
CWS Mn	Skogaholm	Pålsboda W.S.B	510	From Nora.
ØS	Skyllberg	Hallsberg W. S. B.	800	From Nora.

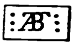
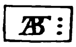
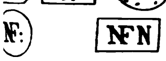
Mark.

Name of works.	Post Office.	Annual production in tons.	Principal ores.
Stjernfors	Nya Kopparberg	470	From Lomberg and Svartvik, etc.
Svartå	Svartå N.W.S.B	700	From Dalkarlsberg, Striberg, Viker, & Persberg.
Walåsen	Carlskoga	360	Id.
Willingsberg	Örebro	500	Id.
Wrethammar	Ramsberg	130	From Stråssa and Blanka.
Åbyhammar	Arboga	170	
PROVINCE OF SKARABORG.			
Forsvik	Karlsborg	300	From Nora
Fredriksfors	Wassbacken	270	Id.
Lagerfors	Moholm W.S.B.	300	Id.
Ribbingsfors	Mariestad	350	Id.
Skagersholm	Finnerödja W. S. B.	430	Id.
PROVINCE OF CARLSTAD.			
Ackhärn	Christinehamn	550	From Filipstad.
Bada Ö	Sunne	150	Id.
Björneborg and Jonsbol	Christinehamn	1,000	From Persberg, Dalkarlsberg, Streberg, & Viker.
Borgvik and Brunsberg	Carlstad	2,000	From Persberg.
Brattfors, etc.	Id.	850	Id.
Charlottenberg	Arvika	400	From Persberg and Nora.
Dömle	Carlstad	470	From Filipstad.
Edsvalla	Id.	940	Id.
Elfsbacka	Carlstad	1,280	From Nordmark and Finshytta.
Fredros	Arvika	425	
Glasfors	Ökne	340	
Gustafström	Grythyttehed	550	From Persberg, Björnhöjde, Fagerberg, and Långvan.
Helybodafors	Arvika	160	

Mark.	Name of works.	Post Office.	Annual production in tons.	Principal ores.
K:	Håkaubol	Åtorp	230	From Dalkarlsberg.
CHH KB P S	Högfors	Sunne	630	
BE UvA	Kolsäter	Ökne	210	
J.S. OPS/C	Krontorp	Christinehamn	370	
RF, GF, IE, UF.	Lennartsfors	Ökne	800	
LP GE	Lesjöfors	Filipstad	1,200	From Långban and Persberg.
NM JC& CGO	Lethafors	Råda	220	
K: P.G	Lidefors Ö	Åtorp	150	From Dalkarlsberg and Striberg.
K: OL	Lidefors N	Id	160	Id.
S:H LNS	Lindfors	Carlstad	850	From Persberg.
ÖAS MM	Löfstaholm	Sunne	280	
MFS	Mitandersfors	Id	200	
OK MB	Mölnbacka	Carlstad	850	From Persberg.
GL Nm	Niclasdam	Christinehamn	280	
INN	Noreborg	Arvika	140	
HK N	Norum	Carlstad	150	
Q	Qvarntorp	Id	170	
IGG	Ransäter Ö	Id	160	
F EF	Ransäter M	Id	180	
HK CGG	Ransäter N	Id	160	
RD RH GS	Rottnedal	Sunne	640	
6 LTD 6	Rämen or Liljendal	Filipstad	680	From Långban, Persberg, and Filipstad.
IL Ł W CIG SB	Storfors	Christinehamn	1,530	From Persberg and Nykroppa.
HK	Stömned	Carlstad	260	
CÜ ÜG	Svaneholm	Åmål	460	From Filipstad.

Mark.	Name of works.	Post Office.	Annual production in tons.	Principal ores.
WR RF	Sälboda	Arvika	1,230	From Persberg.
	Thorsby	Sunne	630	
LB ÆB C.F ØF W.F	Uddeholm	Råda	4,300	From Taberg, Nordmark, Persberg and Långban.
OPS	Wassgårda	Christinehamn	230	
	Wägsjöfors	Sunne	170	
	PROVINCE OF ELFSBORG.			
BF	Bäckefors	Åmål	1,520	From Persberg.
D LF	Christinedal	Id	460	
IGE GM	Forsbacka	Id	390	
KB	Kollerö	Uddevalla	700	
V	Upperad	Wenersborg	320	
	PROVINCE OF NYKÖPING.			
F	Forssa	Katrineholm W.S.B.	260	
Z	Forssjö	Id	310	From Skalunda, etc.
K	Krämbol	Id	230	
Ny	Nyby	Thorshälla	340	
	Nyköping	Nyköping	630	
	Skepsta (steel)	Björnlunda W. S. B.	350	
	Smedstorp	Malmköping	170	From Staf.
GS W	Virå	Norrköping	260	
	PROVINCE OF ÖSTERGÖTLAND.			
B R	Borggård	Tjellmo	260	
I◇B	Borkhult	Söderköping	190	From Utö, etc

Mark.	Name of works.	Post Office.	Annual production in tons.	Principal or
B b	Boxholm	Boxholm	640	
(B)	Börggjöl	Norrköping	160	
(ƎE) F:G TGE N:G	Finspong	Id	2, 200	From Upsala, Utö, etc.
C:F:	Folkström	Tjellmo	510	
(DC)	Godegård	Hallsberg W. S. B.	270	From Nora and S
CDB	Grytgjöl	Tjellmo	180	
H	Hult	Norrköping	250	
(HJ)	Håfla	Id	600	From Nora.
(NT)	Hättorp	Tjellmo	170	
Æ L	Ljung	Linköping	550	
(Lå)	Lemneå	Tjellmo	310	
(MW)	Motala Werkstad	Motala	2, 100	
·S-C·	Skönnarbo	Tjellmo	380	
.m.	Sonstorp	Norrköping	550	
PROVINCE OF CALMAR.				
(Am) (A)	Ankarsrum	Westervik	830	From Stenbo, Sjösa, Herräng, berg.
E	Ed	Söderköping	280	From Stenbo,] Utö, and Narto
(IB)	Falsterbo	Westervik	260	From Skramstad, and Utö.
(TF)	Fogelfors	Staby	310	From Striberg a: sta.
(T)	Tofverum	Wimmesby	170	
(Ö)	Öfverrum	Åtvidaberg	350	From Sjösa, Uti näs, Olofsrum,

Mark.	Name of works.	Post Office.	Annual production in tons.	Principal ores.
	PROVINCE OF JÖNKÖPING.			
	Eckersholm	Jönköping	140	From Taberg.
	Göthafors	Id	180	Id.
	Hörle	Wernamo	390	Id.
	Lindefors	Wrigstad	290	Id.
	Nissafors	Jönköping	370	From Taberg and Nora.
	PROVINCE OF KRONOBERG.			
	Böksholm	Wexiö	160	
KS	Klafreström	Id	150	
	Lessebo	Id	240	
	Orrefors	Id	240	
	Stenfors	Id	210	
	Säfsjöström	Id	190	

For information as to the prices and qualities of the irons, one can write directly to the forges themselves. For example: "Brukskontoren à Säfsjöström, Wexiö, Sweden;" or: "Brukskontoret à Nissafors, Jönköping, Sweden," etc.

But as all the marks are not indicated here, and since all the forges have agents, it will be better to ask the name of their agent, who will be able to give all the necessary information.

APPENDIX C.

LUNDIN'S FURNACE.

The following table shows the results for the first year of working c the saw-dust heating furnace, at Munkfors during the year 1866, com pared with the results obtained from the charcoal furnaces of the Societ of Uddcholm. The two coal furnaces served at the same time a reserves, and have only been worked when the other was under repair During the first six months the yield was 789 tons of bar iron, and i the last six months 1,013 tons, of which 557 tons was during the las three months, or at the rate of 2,229 tons per year.

The column containing the consumption of carbon of wood not coke per ton is calculated on the assumption that a cubic foot of charcoa contains eight pounds of pure carbon, and that 50 per cent. of the rich ness of the wood in carbon is lost in coking. The column shows, there fore, the real consumption of carbon per ton of iron made.

In comparing the consumption of fuel in the saw-dust furnace wit that of the charcoal furnaces, it will be seen that the first was able t heat three hundred weight of iron with the same quantity of combust ble that the latter would have required for one hundred weight. an this though the former works with wet fuel.

The latest results of the saw-dust furnace are as follows: Fro November 10, 1866, to April 18, 1867, or during 105 days of 24 hours, yield of 926 tons of bar iron, with a waste of 12.04 per cent., and wi 268 cubic feet saw-dust per ton of iron. One week showed a yield (56.18 tons, with 219 cubic feet per ton, the waste being only 9.9 per cen At present the waste does not exceed 11 per cent. (April, 1867.)

Table showing the results of the working of the saw-dust furnace at Munk fors during the year 1866, *comparatively, with the results obtained from the charcoal furnaces of the Society of Uddcholm.*

Year of operation, 1866.	Time in days (24 hours) and hours.	Loops, tons.	Iron detached from the loops and ends cut from bars, tons.	Iron drawn into bars, tons.	Waste, per cent.	Consumption, per ton.				Maximum yield of a single furnace per week tons
						Cubic feet saw-dust.	Cubic feet char-coal.	Pounds of wood not coked.	Hours.	
Saw-dust furnace at Munkfors.	206. 11	1, 839. 96	104. 99	1, 532. 30	11. 77	274	......	836	0. 31	57. 59
Two charcoal furnaces at Munkfors	47. 2	325. 62	18. 20	269. 94	12. 19	......	133	2, 134	0. 83	20. 64
Sum	253. 13	2, 165. 58	123. 19	1, 802. 24	......	......	......	......	......	......
Charcoal furnace at Stjernfors	263. 8	1, 024. 08	54. 12	885. 90	12. 18	......	157	2, 530	0. 75	23. 29
Charcoal furnace at Gustafsfors	284. 4	1, 076. 77	46. 68	893. 53	13. 26	......	168	2, 706	0. 75	22. 22
The preceding four years, average—										
Charcoal furnace at Munkfors	274. 21	1, 067. 72	54. 35	889. 87	12. 19	......	133	2, 134	0. 75	23. 34
Charcoal furnace at Stjernfors	259. 1	949. 35	41. 22	793. 08	12. 66	......	166	2, 662	0. 78	23. 04
Charcoal furnace at Gustafsfors	264. 9	1, 008. 65	47. 80	836. 97	12. 89	......	157	2, 530	0. 75	22. 6[illegible]

EXPLANATION OF LUNDIN'S FURNACE.

Plate I.

All the parts of the furnace are easy to manage, and all the work is regular and solid. The reheating furnace is rarely repaired oftener than every five or six weeks; the repairs only require one or two days at most. The most frequent are only the upper portions of the regenerators, which require to be changed. The condenser is only opened and examined two or three times per year. The gas generator is not cleaned during the week, unless this precaution is rendered necessary by the use of impure saw-dust, or dust mixed with sand; and, in any case, this presents no obstacle to the work. Usually the cinders formed during the week are piled at the side of the neighboring wall every Saturday evening when the work is finished, and it is not necessary to undertake a careful cleaning or to remove the refuse, except when the generators are prepared. The tube of the conduit between the gas generator and the condenser requires to be cleaned every week; but this cleaning, which can be easily made during the working of the furnace, does not prevent the heating. Also, generators of a larger size require cleaning much less often.

SUPPLEMENT BY LUNDIN.

a. This is only the hygroscopic value of the water. Dust containing a larger quantity of water may be employed. Fresh dust often contains 50 per cent. That containing 60 per cent. cannot be used long alone, (this makes 80 per cent. by the addition of the chemical water,) but, mixed with pieces of wood or with good dust, it may be employed with advantage.

b. The quantity of carbonic acid may be removed by the use of quicklime in the condensing water. The lime may subsequently be used for agricultural purposes, but the effect of the acid is seldom considerable.

c. The auxiliary furnace has worked since January, 1866, from the same generators and condensers which belong to the heating furnace. At present 21 to 28 cubic feet of saw-dust are consumed for the heating and incandescence of a hundred-weight of iron in bars. In the charcoal gas furnace 10½ to 13 cubic feet of coal are employed, and sometimes more. Consequently, the real consumption of carbon in the latter is 100 pounds to one hundred-weight per hundred-weight of iron, on account of the loss by the burning of the wood.

d. The two or three upper layers of the generators of the heating furnace must ordinarily be renewed every four or six weeks, but the other layers, as well as the regenerators in the auxiliary furnace, last much longer.

y, z. Tube for the water which cools the gas by means of eight streams having a diameter of ⅕ inch. The jets are broken against points of copper directed towards the centre of the openings of the jets. The pressure of the gas in all the conduits is ⅛ inch of water.

Condenser of cast-iron plates.—This contains 3,700 pounds of iron, in bars, kept cool by water from the pipe *y y*, in order to cool the gas and precipitate the water. Fifteen and a half gallons of water, heated to 30° Centigrade, flow in a minute when working with the reheating furnace alone. Nearly double will be required when working with the auxiliary furnace at the same time.

Thirty-six gallons of tar are collected per week.

The tube *y y* turns back and forward by an angle of 120°, to wet the bars, situated below, by means of small holes.

Reheating furnace with Siemens' regenerators.—The furnace may be placed at a long distance from the condenser. The temperature calculated from the cold air used to burn the gas is about 2,000° Centigrade.

The following shows the composition of the gas, which is the same before and after the condensation:

Constituents of the gas.	Volume.	Weight.
Carbonic acid	11.8	19.6
Carbonic oxide	19.8	20.8
Hydrogen	11.3	0.87
"Marsh gas"	4.0	2.4
Nitrogen	53.1	56.3

The mixture before condensation contains 33 parts by weight of water to 100 of dry gas. (For other details, see explanations upon the plate.)

APPENDIX D.

RESULTS OF EXPERIMENTS BY DAVID KIRKALDY ON BESSEMER STEEL AND SWEDISH IRON.

General abstract of the results of experiments to ascertain the mechanical properties of eleven bars of billet iron from the Degerfors Iron Works, Sweden.

Brand.	PULLING STRESS: LENGTH = NINE DIAMETERS.							THRUSTING STRESS: LENGTH = ONE DIAMETER.					BENDING STRESS: DISTANCE BETWEEN SUPPORTS = 20 INCHES.								
	Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ratio of elastic to ultimate.	Contraction of area at fracture.	Ultimate permanent extension.	Effects.	Test number.	Ultimate stress per square inch.	Ultimate permanent depression.		Effects.	Test number.	Elastic stress.	Ultimate stress.	Ratio of elastic to ultimate.	Deflection with 2,000 lbs. pr. BD^2.	Elastic stress. $\frac{}{B D^2}$.	Ultimate stress. $\frac{}{B D^2}$.	Value of S. $S = \frac{L W}{4 B D^2}$.	Effects.
+	B	*Lbs.*	*Lbs.*	*Pr.ct.*	*Pr.ct.*	*Pr.ct.*		B	*Lbs.*	*Inch.*	*Pr.ct.*		B								
H..	1617	20,500	43,032	47.6	71.7	40.0	Fractured very slowly.	1598	100,000	.323	28.6	Bulged, uncracked.	1621	7,250	15,404	47.1	2.26	1,057	2,246	11,230	Uncracked;—bent 5 inches.
H..	1597	19,500	42,624	45.8	73.6	42.7	....do......	1608	100,000	.327	29.0	....do.....	1616	7,250	15,412	47.0	2.32	1,057	2,247	11,235	Do.
H..	1607	19,000	42,528	44.7	72.7	40.5	....do......	1618	100,000	.329	29.2	....do.....	1606	7,100	15,110	46.9	2.58	1,034	2,203	11,015	Do.
H..	1622	19,000	41,548	45.7	73.6	40.2	....do......	1623	100,000	.335	29.7	....do.....	1596	6,950	14,890	46.7	2.66	1,013	2,176	10,855	Do.
		19,500	42,433	45.9	72.9	40.8			100,000	.328	29.1			7,138	15.204	46.9	2.46	1,040	2,217	11,084	
AW	1323	18,500	41,832	44.2	69.8	40.8	....do......	1324	100,000	.328	29.1	....do.....	1312	7,200	15,616	46.1	2.15	1,049	2,276	11,380	Do.
AW	1313	18,000	41,924	43.0	67.8	38.1	....do......	1314	100,000	.347	30.7	....do.....	1322	7,050	15,060	46.7	2.44	1,028	2,196	10,980	Do.
		18,250	41,878	43.6	68.8	39.5			100,000	.338	29.9			7,125	15,338	46.4	2.30	1,038	2,236	11,180	
WC	1293	20,000	44,532	44.9	55.8	31.5	....do......	1299	100,000	.320	28.3	....do.....	1287	7,200	15,728	45.8	1.88	1,049	2,293	11,465	Do.
WC	1298	19,750	43,780	45.1	75.4	40.0	....do......	1294	100,000	.328	29.1	....do.....	1292	6,780	15,320	44.2	2.37	988	2,234	11,170	Do.
WC	1303	18,000	42,048	42.8	73.6	41.2	....do......	1304	100,000	.348	30.8	....do.....	1297	6,500	15,256	43.2	2.45	947	2,224	11,120	Do.
WC	1288	18,500	40,272	45.9	74.5	39.6	....do......	1289	100,000	.351	31.1	....do.....	1302	6,400	15,020	42.6	2.50	933	2,189	10,945	Do.
WC	1308	17,750	40,096	44.2	66.8	36.4	....do......	1309	100,000	.370	32.8	....do.....	1307	6,250	14,318	43.6	3.14	911	2,087	10,435	Do.
		18,800	42,145	44.6	69.2	37.7			100,000	.343	30.4			6,626	15,128	43.8	2.47	965	2,205	11,026	

DAVID KIRKALDY.

GROVE, SOUTHWARK STREET, LONDON, S. E., *July* 20, 1867, Messrs. A. FRODING & CO., *Gothenburg, Sweden*, per Mr. S. H. LUNDH, 9B, *New Broad street, London*.

Results of experiments to ascertain the resistance to extension, set, and rupture, under a pulling stress, and to permanent depression under a thrusting stress, of four Fagersta steel wire billets, manufactured by Christian Aspelin, esq., Sweden.

PULLING STRESS.

Test number.	Billets stamped.	Description.	ORIGINAL.		STRESS IN POUNDS PER SQUARE INCH.—EXTENSION AND SET, INCH.																			
			Diam.	Area.	20,000.	21,000.	22,000.	23,000.	24,000.	25,000.	26,000.	27,000.	28,000.	29,000.	30,000.	31,000.	32,000.	33,000.	34,000.	35,000.	36,000.	37,000.	38,000.	39,000.
B.																								
1405	0.1	Turned down and polished.	1.128	1.0000	.040 Set.	.041	.043	.044	.045	.047	.048	.050	.052	.054	.056	.057	.058	.059	.060	.062	.063	.064	.066	.067
1404	0.1	.....do	1.128	1.0000	.040 Set.	.042	.043	.044	.046	.047	.048	.049	.050	.052	.053	.055	.057	.058	.060	.062	.064	.071	.084 .018	.132
1403	0.1	.....do	1.128	1.0000	.040 Set.	.042	.044	.046	.048	.051	.058	.065	.070	.078	.087	.108	.143	.173	.218	.251	.303	.332	.391	.484
1406	0.1	.....do	1.128	1.0000	.036	.037	.038	.042	.050 .010	.060	.010 0.71 .028	.088	.020 .102 .051	.118	.038 .138 .082	.167	.080 .215 .180	.269	.158 .304 .234	.335	.238 .398 .332	.429	.324 .500 .432	.542

Test number.	STRESS IN POUNDS PER SQUARE INCH.—EXTENSION AND SET, INCH.														Ultimate stress per sq. inch of original area.	FRACTURED.				Ultimate stress per sq. inch of fractured area.	EXTENSION.	
																Diam.	Area.	Difference.				
	40,000.	41,000.	42,000.	43,000.	44,000.	45,000.	46,000.	47,000.	48,000.	49,000.	50,000.	51,000.	52,000.	53,000.				Area.	Per cent.		Total.	Per cent.
B.															*Pounds.*	*Inch.*	*Sq. inch.*	*Sq. inch.*		*Pounds.*	*Inch.*	
1405	.069	.070	.071	.072	.073	.139	.150	.166	.191	.217	.261	.291	.360	.401	53,924	.61	.2922	.7078	70.78	184,545	1.08	10.8
1404	.146 .070	.166	.196 .124	.220	.254 .176	.059 .293	.073 .347 .268	.380	.111 .458 .376	.521	.173 .666 .577	.866	.261	......	51,640	.57	.2552	.7448	74.48	202,351	1.61	16.1
1403	.518 .446	.568	.653 .576	.748	.868 .788	1.04	1.25 1.15	1.56	......	......	......	......	......	......	47,392	.58	.2642	.7358	73.58	179,380	2.10	21.0
1406	.650 .577	.720	.832 .752	.935	1.10 1.02	1.31	1.65 1.56	......	......	......	......	......	......	......	46,896	.57	.2552	.7448	74.48	183,761	2.51	25.1

Results of experiments to ascertain the resistance to extension, set, and rupture, under a pulling stress, &c.—Continued.

THRUSTING STRESS.

Test number.	Billets stamped.	Description.	ORIGINAL. Height.	Diameter.	Area.	STRESS IN POUNDS PER SQUARE INCH.—PERMANENT DEPRESSION, INCH. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B			*Inch.*	*Inch.*	*Square inch.*										
1401	0.1	Turned down and polished	1.127	1.128	1.0000	.000	.020	.040	.070	.104	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1402	0.1	......do............do	1.126	1.128	1.0000	.000	.020	.054	.080	.120	.164	[illegible]	[illegible]	[illegible]	417
1399	0.1	......do............do	1.127	1.128	1.0000	.000	.030	.050	.080	.131	.169	[illegible]	[illegible]	[illegible]	[illegible]
1400	0.1	......do............do	1.124	1.128	1.0000	.010	.031	.055	.087	.141	.184	[illegible]	[illegible]	[illegible]	[illegible]

Test number.	STRESS IN POUNDS PER SQUARE INCH.—PERMANENT DEPRESSION, INCH. 116,000.	124,000.	132,000.	140,000.	148,000.	156,000.	164,000.	172,000.	180,000.	188,000.	196,000.	Ultimate stress per square inch.	Ultimate permanent depression.		Remarks.
B												*Pounds.*	*Inch.*	*Per cent.*	
1401	.360	.392	.420	.442	.466	.494	.515	.528	.546	.560	.576	200,000	[illegible]	[illegible]	Unfractured.
1402	.356	.385	.412	.436	.460	.482	.500	.519	.536	.550	.566	200,000	[illegible]	[illegible]	Ditto.
1399	.367	.394	.421	.472	.476	.500	.520	.542	.556	.572	.590	200,000	[illegible]	[illegible]	Ditto.
1400	.378	.413	.440	.462	.487	.502	.522	.545	.556	.571	.590	200,000	[illegible]	[illegible]	Ditto.

GROVE, SOUTHWARK STREET, LONDON, S. E., *June* 1, 1867.

DAVID KIRKALDY.

CHRISTIAN ASPELIN, Esq., *Norberg and Fagersta, Sweden.*
Agent, Mr. S. H. LUNDH, 9B, *New Broad Street, London.*

General abstract of the results of experiments to ascertain the mechanical properties, &c., of twelve hammered bars of Fagersta steel of various degrees of hardness, manufactured by Christian Aspelin, esq., Sweden.

Bars stamped.	PULLING STRESS: LENGTH = NINE DIAMETERS.							THRUSTING STRESS: LENGTH = ONE DIAMETER.					
	Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ratio of elasticity to rupture.	Contraction of area at fracture.	Ultimate permanent extension.	Effects.	Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ultimate permanent depression.		Effects.
	B	*Lbs.*	*Lbs.*	*Per ct.*	*Per ct*	*Per ct.*		B	*Lbs.*	*Lbs.*	*Inch.*	*Per ct.*	
1.2	1068	63,000	81,952	76.8	3.23	1.7	Fractured suddenly	1070	65,000	200,000	.278	24.6	Bulged.
1.2	1078	60,000	81,424	73.7	1.48	1.4	....do	1080	63,000	200,000	.215	19.0	Ditto.
1.2	1088	63,500	92,224	68.8	3.23	2.2	....do	1090	64,000	200,000	.216	19.1	Ditto.
		62,167	85,200	73.1	2.65	1.8			64,000	200,000	.236	20.9	
0.9	1098	63,000	112,976	55.8	4.97	3.7	....do	1100	65,000	200,000	.222	19.7	Ditto.
0.9	1108	63,000	109,952	57.3	8.39	7.9	....do	1110	63,000	200,000	.265	23.5	Ditto.
0.9	1118	63,000	96,912	65.0	4.97	3.6	....do	1120	60,000	200,000	.270	23.9	Ditto.
		63,000	106,613	59.4	6.11	5.1			62,666	200,000	.252	22.4	
0.6	1128	63,000	101,232	62.2	21.46	5.5	....do	1130	62,000	200,000	.290	25.7	Ditto.
0.6	1138	53,000	97,968	54.1	10.08	5.7	....do	1140	56,000	200,000	.314	27.8	Ditto.
0.6	1148	58,000	108,696	53.4	11.75	8.7	....do	1150	62,000	200,000	.278	24.6	Ditto.
		58,000	102,632	56.6	14.43	6.6			60,000	200,000	.294	26.0	
0.3	1158	45,000	61,288	73.4	61.52	22.1	Slowly ...	1160	38,000	200,000	.546	48.4	Ditto.
0.3	1168	41,000	63,120	64.9	60.42	16.2	....do	1170	41,000	200,000	.522	46.2	Ditto.
0.3	1178	43,000	59,528	72.2	62.61	11.2	....do	1180	38,000	200,000	.562	49.8	Ditto.
		43,000	61.312	70.3	61.52	16.5			39,000	200,000	.543	48.1	

General abstract of the results of experiments, &c.—Continued.

Bars stamped.	THRUSTING STRESS: LENGTH = TWO DIAMETERS.						THRUSTING STRESS: LENGTH = FOUR DIAMETERS.					
	Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ultimate permanent depression.		Effects.	Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ultimate permanent depression.		Effects.
	B	*Lbs.*	*Lbs.*	*Inch.*	*Per ct.*		B	*Lbs.*	*Lbs.*	*Inch.*	*Per ct.*	
1.2	1071	65,000	157,920	....	......	Detruded..	1072	63,000	124,260	.486	10.8	Skewed.
1.2	1081	62,000	175,800	....	......	....do	1082	63,000	140,120	.222	4.9	Ditto.
1.2	1091	63,000	176,000	.775	34.4	Skewed ...	1092	61,000	135,610	.492	10.9	Ditto.
		63,333	169,907					62,333	133,333	.400	8.9	
0.9	1101	58,000	184,000	.702	31.2	....do	1102	57,000	135,800	.410	9.1	Ditto.
0.9	1111	59,000	179,860	....	......	Detruded..	1112	59,000	115,880	.390	8.7	Ditto.
0.9	1121	59,000	156,000	.410	18.2	Skewed ...	1122	60,000	100,000	.112	2.5	Ditto.
		58,666	173,287					58,666	117,560	.304	6.8	
0.6	1131	60,000	156,000	.470	20.9	....do	1132	55,000	100,000	.143	3.2	Ditto.
0.6	1141	52,000	156,000	.638	28.4	....do	1142	50,000	100,000	.180	4.0	Ditto.
0.6	1151	60,000	156,000	.442	19.7	....do	1152	55,000	116,000	.422	9.4	Ditto.
		57,333	156,000	.517	23.0			53,333	105,333	.248	5.5	
0.3	1161	43,000	140,000	1.02	45.3	....do	1162	40,000	82,260	.931	20.7	Buckle[illegible]
0.3	1171	43,000	124,000	0.92	40.9	....do	1172	40,000	71,920	.502	11.2	Ditto.
0.3	1181	40,000	100,000	.547	24.3	....do	1182	43,000	91,100	1.10	24.4	Ditto.
		42,000	121,333	.829	36.8			41,000	81,760	.844	18.8	

General abstract of the results of experiments, &c.—Continued.

Bars stamped.	THRUSTING STRESS: LENGTH = EIGHT DIAMETERS. Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ultimate permanent depression.		Effects.	Bars stamped.	SHEARING STRESS: ON EACH END OF SPECIMEN. Test number.	Shearing stress per square inch.	Pulling stress per square inch.	Ratio of shearing to pulling stress.	Distortion before rupture.	Effects.
	B	*Lbs.*	*Lbs.*	*Inch.*	*Pr. ct.*			B	*Lbs.*	*Lbs.*	*Pr.ct.*	*Inch.*	
1.2	1073	60, 000	94,200	.325	3. 6	Buckled.	.2	1074	62, 425	81,952	76. 2	.192	Fractured.
1.2	1083	63, 000	112,320	......	......	Buckled and	.2	1084	58, 050	81,424	71. 3	.179	Do.
						then snap-	.2	1094	63, 760	92,224	69. 1	.208	Do.
						ped.			61, 412	85,200	73. 3	.193	
1.2	1093	62, 000	100,000	.164	1. 8	Buckled.	0. 9	1104	82, 250	112,976	72. 8	.286	Do.
		61, 666	102,173				0. 9	1114	82, 140	109,952	75. 6	.222	Do.
0.9	1103	57, 000	97,100	.448	5. 0	Do.	0. 9	1124	74, 880	96,912	77. 2	.240	Do.
0.9	1113	58, 000	92,300	.312	3. 5	Do.			79, 737	106,613	75. 2	.249	
0.9	1123	59, 000	96,220	.212	2. 4	Do.	0. 6	1134	73, 910	101,232	73. 0	.280	Do.
		58, 000	95,207	.324	3. 6		0. 6	1144	69, 985	97,968	70. 0	.275	Do.
0.6	1133	54, 000	83,000	.342	3. 8	Do.	0. 6	1154	71, 050	108,696	65. 4	.288	Do.
0.6	1143	50, 000	82,500	.383	4. 3	Do.			71, 648	102,632	69. 5	.281	
0.6	1153	54, 000	88,980	.340	3. 8	Do.	0. 3	1164	43, 110	61,288	70. 3	.328	Do.
		52, 666	84,827	.355	4. 0		0. 3	1174	49, 170	63,120	77. 8	.341	Do.
0.3	1163	37, 000	47,920	.402	4. 5	Do.	0. 3	1184	43, 950	59,578	73. 8	.300	Do.
0.3	1173	43, 000	45,500	.442	4. 9	Do.			45, 410	61,312	74. 0	.323	
0.3	1183	42, 000	49,120	.460	5. 1	Do.							
		40, 666	47,513	.435	4. 8								

General abstract of the results of experiments, &c.—Continued.

TWISTING STRESS: LENGTH OF LEVER = TWELVE INCHES.—LENGTH FOR TORSION = EIGHT DIAMETERS.

Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ratio of elastic to ultimate.	Ultimate torsion.	Effects.
B	*Lbs.*	*Lbs.*	*Per cent.*	1 *turn* = 1.000.	
1069........	1, 080	1, 849	58. 4	0. 207 0. 220	One end fractured. Other end fractured.
1079........	1, 150	2, 165	51. 3	0. 228 0. 307	One end fractured. Other end fractured.
1089........	1, 175	2, 345	50. 1	0. 375 0. 410	One end fractured. Other end fractured.
	1, 135	2, 120	53. 9	0. 291	
1099........	1, 150	2, 478	46. 4	0. 727 0. 770	One end fractured. Other end fractured.
1109........	1, 075	2, 251	47. 8	0. 625 0. 800	One end fractured. Other end uncracked
1119........	1, 150	2, 280	50. 4	0. 897 0. 938	One end fractured. Other end fractured.
	1, 125	2, 336	48. 2	0. 793	
1129........	1, 075	2, 188	49. 1	0. 897 1. 255	One end fractured. Other end fractured.
1139........	1, 050	2, 233	47. 0	0. 750 1. 040	One end fractured. Other end uncracked.
1149........	1, 125	2, 362	48. 9	1. 013 1. 170	One end fractured. Other end fractured.
	1, 083	2, 261	48. 3	1. 021	

General abstract of the results of experiments, &c.—Continued.

TWISTING STRESS: LENGTH OF LEVER = TWELVE INCHES.—LENGTH FOR TORSION = EIGHT DIAMETERS.

Test number.	Elastic stress per square inch.	Ultimate stress per square inch.	Ratio of elastic to ultimate.	Ultimate torsion.	Effects.
B	*Lbs.*	*Lbs.*	*Per cent.*	1 *turn* = 1.000.	
1159........	750	1,478	50.7	{ 3.053 3.576	One end fractured. Other end fractured.
1169........	780	1,538	50.7	{ 2.535 3.140	One end fractured. Other end uncracked.
1179........	760	1,545	49.2	{ 3.283 3.725	One end fractured. Other end partly fractured.
	763	1,520	50.2	3.219	

General abstract of the results of experiments, &c.—Continued.

Bars stamped.	BENDING STRESS: DISTANCE BETWEEN SUPPORTS = TWENTY INCHES.								
	Test number.	Elastic stress, total.	Ultimate stress, total.	Ratio of elastic to ultimate.	Ultimate deflection.	Elastic stress. $\frac{}{B\ D^2}$	Ultimate stress. $\frac{}{B\ D^2}$	Value of S. $S = \frac{L\ W}{4\ B\ D^2}$	Effects.
	B	*Lbs.*	*Lbs.*	*Pr. ct.*	*Inch.*				
1.2	1075	20,400	30,496	66.9	0.75	2,974	4,446	22,230	Fractured.
1.2	1085	21,200	32,896	69.5	0.72	3,091	4,796	23,980	Do.
1.2	1095	21,800	35,376	61.6	0.87	3,178	5,157	25,785	Do.
		21,133	32,589	66.0	0.78	3,081	4,800	24,000	
0.9	1105	21,800	43,820	50.0	1.46	3,178	6,388	31,940	Do.
0.9	1115	21,200	44,552	47.6	1.62	3,091	6,495	32,475	Do.
0.9	1125	22,100	43,128	51.2	1.38	3,222	6,288	31,440	Do.
		21,700	43,833	49.6	1.49	3,164	6,390	31,950	
0.6	1135	18,800	40,260	46.7	3.15	2,741	5,870	29,350	Do.
0.6	1145	17,800	36,200	49.1	3.56	2,595	5,277	26,385	Uncracked; removed.
0.6	1155	18,400	38,120	48.2	3.22	2,682	5,558	27,790	Do.
		18,333	38,145	48.0	3.31	2,673	5,568	27,840	
0.3	1165	13,700	24,420	56.1	5.22	2,000	3,560	17,800	Do.
0.3	1175	15,200	23,280	65.3	5.05	2,216	3,394	16,970	Do.
0.3	1185	18,400	28,150	65.4	5.05	2,682	4,104	20,520	Do.
		15,767	25,283	62.3	5.11	2,299	3,686	18,430	

DAVID KIRKALDY.

GROVE, SOUTHWARK STREET, LONDON, S. E., *June* 1, 1867.

CHRISTIAN ASPELIN, Esq., *Norberg and Fagersta, Sweden.*

Agent, Mr. S. H. LUNDH, 9B, *New Broad street, London.*

Results of experiments to ascertain the mechanical properties of nine rolled plates of Fagersta steel of various degrees of hardness, manufactured by Christian Aspelin, esq., Sweden.

Plates stamped.	Test number.	Original size.	Original area.	Total ultimate stress.	Ultimate stress per square inch of original area.	Size of fracture.	Area of fracture.	Difference of fractured area.		Stress per square inch of fractured area.	Total extension.	
PULLING STRESS.												
	B	*Inch.*	*Sq. in.*	*Lbs.*	*Lbs.*	*Inch.*	*Sq. in*	*Sq. in.*	*Pr. ct.*	*Lbs.*	*Inch.*	*Pr. ct.*
0.9	1198	2.50 × .28	.700	76,800	109,714	2.19 × .25	.548	.152	21.7	130,000	1.57	15.7
0.9	1199	2.50 × .28	.700	74,250	106,071	2.36 × .26	.614	.086	12.3	130,000	0.86	8.6
0.9	1189	2.52 × .27	.680	70,020	102,972	2.35 × .25	.587	.093	13.7	122,475	0.92	9.2
0.9	1188	2.52 × .27	.680	68,010	100,015	2.25 × .24	.540	.140	20.6	122,475	1.35	13.5
0.9	1194	2.50 × .27	.675	65,160	96,533	2.44 × .26	.634	.041	6.1	100,480	0.47	4.7
0.9	1193	2.50 × .27	.675	62,550	92,666	2.45 × .26	.637	.038	5.6	100,480	0.41	4.1
					101,328				13.3	117,653		9.3
0.6	1213	2.50 × .28	.700	70,670	100,956	2.29 × .25	.573	.127	18.1	127,012	1.24	12.4
0.6	1214	2.50 × .28	.700	70,440	100,630	2.24 × .24	.538	.162	23.1	127,012	1.11	11.1
0.6	1204	2.50 × .28	.700	73,280	100,469	2.40 × .26	.624	.076	10.9	125,540	0.68	6.8
0.6	1203	2.50 × .28	.700	67,450	96,357	2.16 × .23	.497	.103	14.7	125,540	1.64	16.4
0.6	1208	2.48 × .28	.694	66,910	96,412	2.20 × .24	.528	.166	24.0	111,218	1.42	14.2
0.6	1209	2.48 × .28	.694	60,880	87,240	2.39 × .26	.621	.073	10.5	111,218	0.69	6.9
					97,011				16.9	121,257		11.3
0.3	1640	2.51 × .25	.627	49,940	79,650	2.03 × .17	.345	.282	45.0	126,484	1.29	12.9
0.3	1639	2.51 × .25	.627	46,820	74,637	2.10 × .20	.420	.207	33.0	126,484	1.92	19.2
0.3	1649	2.51 × .27	.677	47,440	70,074	2.07 × .15	.310	.367	54.2	138,554	1.91	19.1
0.3	1650	2.51 × .27	.677	45,530	67,253	2.12 × .17	.361	.316	46.7	138,554	1.00	10.0
0.3	1645	2.51 × .25	.627	43,415	69,242	2.00 × .17	.340	.287	45.8	125,900	1.27	12.7
0.3	1644	2.51 × .25	.627	40,055	63,884	2.02 × .17	.323	.304	48.5	125,900	1.94	19.4
					70,790				45.5	130,313		15.5

***Results of experiments to ascertain the mechanical properties, &c.*—Contin'd.**

stamped.	Test number.	Thickness of plate.	Stress in pounds. Bulged, inch.					Ultimate.	
BULGING STRESS.									
			5,000.	25,000.	50,000.	75,000.	100,000.	Bulge.	Stress.
	B								
0.9	1202	0.28	.123	.756	1.25	1.60	2.00	2.00	100,000
0.9	1197	0.27	.149	.846	1.42	1.81	2.22	2.59	120,000
								2.30	111,000
0.6	1212	0.28	.145	.759	1.31	1.73	2.14	2.52	120,000
0.6	1207	0.28	.153	.812	1.37	1.80	2.23	2.61	120,000
								2.57	120,000
0.3	1643	0.25	.208	.987	1.74	2.39	....	3.68	99,760
0.3	1648	0.25	.211	1.03	1.77	2.42	....	4.40	98,432
								4.04	99,096

Results of experiments to ascertain the mechanical properties, &c.—Cont'd.

PUNCHING STRESS.

Stamped.	Test No.	Thickness.	Ultimate stress per square inch.		Stamped.	Test No	Thickness.	Ultimate stress per square inch.	
	B					B			
0.9	1201	0.28	78,200	76,320	0.6	1205	0.28	72,200	70,350
0.9	1200	0.28	77,200	76,940				74,217	
0.9	1191	0.27	75,290	74,380	0.3	1651	0.27	53,900	53,150
0.9	1190	0.27	74,330	73,360	0.3	1652	0.27	53,000	52,980
			75,752		0.3	1642	0.25	49,860	49,840
0.6	1216	0.28	77,830	77,220	0.3	1641	0.25	49,420	49,260
0.6	1215	0.28	75,620	75,100				51,426	
0.6	1206	0.28	73,150	71,270					

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APPENDIX E.

TRANSCRIPTS OF PRUSSIAN, FRENCH, AND ENGLISH LAWS, UNDER WHICH CO-OPERATIVE ASSOCIATIONS ARE ORGANIZED.

PRUSSIAN LAW GRANTING CORPORATE RIGHTS TO CO-OPERATIVE ASSOCIATIONS.

We, William, by the grace of God King of Prussia, &c., enact, with the consent of the two houses of our Landtag, as follows:

PART I.—OF THE FORMATION OF THE ASSOCIATION.

SECTION 1. Societies with unlimited membership, whose object it is by the transaction of business in common to enlarge credit, increase the trade, profits, and further the household economy of their members, viz.:

1. Loan and credit unions;
2. Raw material and store unions;
3. Unions for the production and sale of finished wares on a common account, (productive association;)
4. Unions for the purchase of the necessaries of life wholesale and the selling them retail, (consumption associations;)
5. Unions for providing members of such unions with dwelling houses;

Acquire under the conditions hereinafter described the rights designated in the present law as those of "registered associations."

SEC. 2. The requisites to the constitution of such associations are—

1. The drawing up of the statutes in writing.
2. The assumption of a common name, (firma.)

The name of the association must be derived from the object of the undertaking, and have affixed to it the title "registered association."

Neither the names of the members, (associates,) nor those of any other persons, must appear in the name of the association. Every new name must be clearly distinguished from those of any previously existing registered association in the same locality.

SEC. 3. The statutes must contain—

1. The name and seat of the association.
2. The object of the undertaking.
3. The duration of the association in the event of the same being established for a limited period only.
4. The conditions under which members join and leave the association.
5. The amount of the shares of the several associates, and the way in which these shares are paid up.
6. The principle upon which the balance sheet is drawn up and the profits are reckoned, and the way in which the balance sheet is audited.
7. The mode of election and the composition of the managing body,

Nevertheless, any rights or claims which may have been in force against such effects before they became part of the property of the association are not invalidated by the foregoing paragraphs.

SEC. 14. As long as the association exists, claims of the association cannot be compensated, either in their whole extent or in part, by the private claims which the person indebted to the association can raise against a member of the association.

SEC. 15. If the private creditor of an associate, after fruitlessly distraining upon the private property of such associate, obtains a right of execution upon the share which would accrue to the associate upon the winding up of the concern, he can, whether the association be founded for a limited or unlimited period, demand for the satisfaction of his debt that the associate leave the association. Notice to that effect must, however, be given at least six months previous to the close of the financial year.

PART III.—OF THE MANAGING BODY, THE COUNCIL OF SUPERVISION, AND THE GENERAL MEETING.

SEC. 16. Every association must have a managing body elected from amongst the associates. By it the association is represented judicially and extra-judicially. The managing body can consist of one or more members, who may be salaried or not. It is at all times removable, with a claim, however, to compensation if such arise out of existing contracts.

SEC. 17. The names of the managing body must immediately on their nomination be notified to the commercial tribunal and be entered on the register, and the tribunal must be made acquainted in an official form with their signature.

SEC. 18. The managing body sign for the association. If the statute contains no particular stipulation on the subject, the signatures of all members of the managing body are required.

SEC. 19. The association obtains rights and is subject to obligations in all legal matters entered into by the managing body on their behalf. It is matter of indifference whether such business has been concluded expressly in the name of the association, or whether circumstances prove that it was the will of the contracting parties that it should be concluded for the association.

The competency of the managing body, in representing the association, extends to those affairs and legal proceedings for which the law requires special full powers. To legitimate the managing body in all matters concerned with the registry of mortgages, a certificate of the commercial tribunal, to the effect that the persons designated are the managing body, suffices.

SEC. 20. The managing body is bound to observe the limits placed to its functions by the statutes or by the resolutions of a general meeting. This limitation of the powers of the managing body, however, is not valid as against other persons.

SEC. 21. Oaths can be taken by the managing body in the name of the association.

SEC. 22. Changes in the members of the managing body must be notified and entered on the register.

SEC. 23. In serving writs on, or giving legal notices to, the association, it suffices that this should be done upon, or to, a member of the managing body who is empowered to sign on behalf of the association.

SEC. 24. The managing body is bound, at the end of each quarter, to notify to the commercial tribunal the names of the members who have joined and of those who have left the association during the quarter, and once a year, in January, to give an exact alphabetical list of all the members.

The tribunal rectifies, by these lists, the original list deposited with it.

SEC. 25. The managing body must, within the first six months of each financial year, publish the balance sheet of the preceding year, and the number of the actual members of the association.

SEC. 26. Members of the managing body who have in that capacity acted beyond the limit of their powers, or against the provisions of the present law, or of the statutes of the association, are liable, with their whole estate, for the losses which may accrue out of such acts.

If they busy themselves with other objects than those specified in the present law, (section 1,) or if they allow, or do not prevent, the discussion of subjects at the general meetings which have no reference to the business of the association, but are concerned with public affairs, (see section of the law of March 11, 1841, for the prevention of the misuse of the right of meeting,) they incur a fine of 200 thalers.

SEC. 27. The statutes can provide for the creation, side by side with the managing body, of a council of supervision. This council superintends the administration of the managing body, in all its branches. It acquaints itself with the state of its affairs, inspects the books and the cash balances, and can convoke general meetings. It can, pending the decision of the general meeting, and if it should seem necessary, depose the managing body, and take the necessary measures for the provisional transaction of the business. It must examine the yearly accounts, and report thereon to the general meeting.

SEC. 28. The council of supervision is charged to bring actions at law against the managing body, if the general meeting has resolved on such action.

If the association has to bring actions against members of the council of supervision, it must, by the vote of a general meeting, name persons, with the necessary full powers, to carry on the suit.

Every member of the association is authorized to intervene in the suit, at his own expense.

SEC. 29. Full powers can be given by the association, *ad hoc*, to other persons than the members of the managing body, or the council of supervision; the exact extent of the functions thus vested in these persons being exactly specified in the full power.

SEC. 30. The general meetings are convoked by the executive body, unless otherwise specified in the statute.

General meetings, besides the occasions for such meetings specified in the statute, are to be convoked whenever it appears in the interest of the association to do so.

SEC. 31. The convoking of the general meeting must take place according to the forms fixed by the statutes.

The subjects for discussion must, on every occasion, be notified simultaneously with the convoking. No resolutions can be passed upon subjects of which notice has not thus been given. For the mere proposing of resolutions, and for discussions not ending with a formal resolution, no such notice is required.

SEC. 32. The managing body is bound to observe and execute all the provisions of the statutes, as well as the resolutions of the general meetings passed conformably to the said statutes.

The resolutions of the general meetings must be entered in a register of protocols, which must be open to the inspection of every associate, and of the organs of the government.

PART IV.—OF THE DISSOLUTION OF THE ASSOCIATION, AND THE LEAVING IT BY INDIVIDUAL ASSOCIATIONS.

SEC. 33. The association is dissolved—

1. By the conclusion of the period for which it was formed;
2. By a resolution of the association;
3. By a declaration of bankruptcy.

SEC. 34. If an association is guilty of illegal acts by which the welfare of the community suffers, or if it pursues other objects than those business objects specified in the present law, (sec. 1,) it can be dissolved without claim to compensation.

In such a case the dissolution can only take place upon the passing of a judicial sentence on the prosecution of the district authorities. The competent tribunal is that to whose ordinary jurisdiction the association is subject.

The sentence of the tribunal is to be communicated to the tribunal which keeps the register of the association, that it may be entered therein and published, according to section 36.

SEC. 35. The dissolution of the association, if it does not take place in consequence of a declaration of bankruptcy, must be notified by the managing body for entry in the register of the association, and must be announced three times consecutively in the public journals.

This announcement must besides call upon the creditors of the association to send in their claims to the managing body.

SEC. 36. The declaration of bankruptcy is to be officially entered in the register by the tribunal charged with the bankruptcy proceedings, and notice of the same is likewise to be published in the public papers.

SEC. 37. Every associate has the right to leave the association. I there are no express stipulations in the statutes on the subject, the associate can only leave at the close of the financial year, and must give a four weeks' notice at the least. Membership, moreover, ceases with death, unless the statutes contain stipulations carrying such membership on to the heirs at law.

The association can, on grounds which must be specified in the statute, exclude members from the association.

SEC. 38. The associates who leave, or who are excluded from the association, as also the heirs of deceased members, remain liable for all debts of the association contracted before the date of the cessation of membership, until the period of limitation.

Unless the statutes contain stipulations to the contrary, such persons have no claims on the reserved fund, or the corporate property of the association, and can only demand the repayment of their shares with the dividends accrued upon them, such repayment to be made within three months of their leaving the association.

The association can only protect itself against such a claim, even if the property of the association should have diminished at the time of such cessation of membership, by dissolving itself and proceeding to wind up the business.

PART IV.—OF THE WINDING UP OF THE ASSOCIATION.

SEC. 39. After the dissolution of the association, except in the case of bankruptcy, the winding up of its business is undertaken by the managing body, unless the statutes or a resolution of the association designate some other persons for that purpose. The appointment of the liquidators is always revocable.

SEC. 40. The liquidators must be notified to the tribunal of commerce, and their names entered on the register. If a liquidator vacates his office, or if his power of attorney expires, notice must likewise be given.

SEC. 41. The relations of the liquidators towards other persons are determined by sections 25 and 40 of the General German Commercial Code. If there are several liquidators they can only legally transact business by doing so in common, unless it be specially stipulated that they can do so individually.

SEC. 42. The liquidators have to wind up the current business, to fulfil the engagements of the dissolved association, to call in outstanding claims, and to convert the property of the association into cash. They have to represent the association judicially and extra-judicially; they can compound and make compromises. To wind up current business, they can enter into fresh engagements.

The liquidators can only effect the sale of real property by auction, unless there be stipulations to the contrary in the statute or resolutions of the association.

SEC. 43. The limitations of the functions of the liquidators as against other persons has no legal force.

SEC. 44. The liquidators have to give their signature in such a manner that they affix their names to the former name of the association, which is now to be designated as the name of the union to be wound up.

SEC. 45. The liquidators have, in the management of the business committed into their hands, to conform themselves to the resolutions passed by the general meeting.

SEC. 46. The moneys in the hands of the association at the time of dissolution, and those which during the process of winding up flow into the hands of the liquidators, are to be applied as follows:

(*a.*) First, the creditors of the association are to be satisfied as the money owing to them falls due.

(*b.*) From what remains, the shares, with the dividends accrued upon them, are to be repaid to the associates. If the assets are not sufficient to pay these in full, the distribution takes place according to the relative proportions of the shares.

(*c.*) From what remains after paying the debts of the association and the shares of the members, there will, in the first place, be distributed the profits of the last year as prescribed by the statutes. If any property should then remain, the same, in the absence of special stipulations to that effect, shall be distributed amongst the members per head.

SEC. 47. The liquidators must begin by drawing up a balance-sheet. Should the result of this balance-sheet be that the property of the association (inclusive of the reserve fund and the share capital) does not suffice to cover the debts of the association, the liquidators have at once on their own responsibility to call a general meeting, and hereupon, if within eight days the associates have not contributed sufficiently to cover the deficit, they have to apply for the opening of the commercial bankruptcy in regard to the assets of the association.

SEC. 48. Notwithstanding the dissolution of the association the legal status of the associates *inter se*, and towards other persons, remains until the close of the liquidation the same as that laid down in Parts II and III of the present law. In the event of the dissolution of the association, no member can be made liable by means of regress on account of the smaller amount of the calls on shares which he may have paid according to the statutes, by the other members of the association, who have paid up more on their shares. The jurisdiction under which the union was at the time of its dissolution remains in force for the union which is to be dissolved, till the close of the winding up. Citations addressed to the associations can be delivered to the hand of one of the liquidators.

SEC. 49. After the conclusion of the winding up, the books and papers of the late associations are to be given into the custody of one of the former associates, or of a third person. If agreement cannot be come to as to who this person should be, the tribunal of commerce determine

The associates and their heirs retain the right of examining and using these books.

SEC. 50. Besides the case provided for by section 47, bankruptcy is clared whenever the association, either before or after dissolution, has opped payment. (See section 281, No. 2, of the bankruptcy law, &c. The notice of such stoppage of payment, if before the dissolution of ie association, must be given by the managing body; if afterwards, by ie liquidators.

The association is represented in the one case by the managing body, n the other by the liquidators. Such representatives have to appear ersonally to give the necessary information, as in the case of an ordiiary debtor. A concordate cannot take place.

The declaration of bankruptcy in regard to the corporate property of the association does not involve a declaration of bankruptcy in regard to the private property of the associates.

The decision in regard to the opening of bankruptcy must not contain the names of the members who are jointly and severally liable.

As soon as the bankruptcy proceedings are ended the creditors have the right to recover their claims (only in so far, however, as they were put in and verified during the bankruptcy proceedings, but inclusive of interests and costs) on the private property of the individual associates.

PART VI.—OF THE LIMITATION OF CLAIMS AGAINST ASSOCIATES.

SEC. 51. The limitation of claims against an associate for debts incurred by the association during membership comes into force two years after the dissolution of the association, or after the date of his quitting the association or being excluded from it, in so far as the peculiar character of the claim does not involve a shorter period.

The two years are reckoned from the day on which the dissolution of the association was entered on the register, or the cessation of membership was notified to the tribunal of commerce. If the claim became only due after this date, the time is reckoned from the date at which such claim became due. If there remain undistributed assets, the two years' limitation cannot be enforced against the creditor in so far as he founds his claim only on the corporate property of the association.

SEC. 52. The limitation in favor of a member who has quitted it or been excluded is not interrupted by legal proceedings undertaken against another member of the association, but by legal proceedings undertaken against the still existing association.

The limitation in favor of a member of the association who belonged to it at the time of dissolution is not interrupted by legal proceedings undertaken against the liquidators or the bankruptcy.

SEC. 53. The limitation runs likewise against minors and persons under guardianship, as well as against corporations which legally enjoy the rights of minors, without admittance of the *restitutio in integrum*, but with the proviso of redress against the guardians and administrators.

CONCLUDING PROVISIONS.

SEC. 54. The commercial tribunal holds the managing body to the observance of sections 4, 16, 17, 22, 24, 25, 32, 35, 40, by the infliction of fines and penalties, as provided in section 5 of the introductory portion of the General German Commercial Code of 24th June, 1861.

Inaccuracies in the notices given by the managing body are to be fined 20 thalers.

SEC. 55. Section 55 does not exclude more rigorous measures, if they are enjoined by other laws.

SEC. 56. The registrations take place free of cost. The details respecting the way in which the registers shall be kept will be given in a general instruction, to be drawn up by the ministers for commerce, industry, and public works, and justice.

The ministers aforesaid are charged with the enforcement of the present law.

FRENCH LAW OF COMPANIES.

[Extract from the French law of "Companies," of 24th to 29th January, A. D. 1867.]

TITLE III.—PARTICULAR PROVISIONS FOR SOCIETIES WITH VARIABLE CAPITAL.

ART. 48. It may be stipulated in the by-laws of any society that the capital of the society will be susceptible of augmentation by successive payments made by the members or the admission of new members, and of diminution by the withdrawal, total or partial, of the payments already made.

The societies whose by-laws shall contain the above stipulation will be subject, independently of the general rules which apply to them according to their particular form, to the provisions of the following articles:

ART. 49. The capital of the society may not be fixed by the constituting laws of the society above the sum of 200,000 francs. It may be augmented by the deliberations of the general assembly held from year to year. Each augmentation may not exceed 200,000 francs.

ART. 50. The shares or coupons of shares will bear the name of an individual. Even after their entire liberation they may not be less than 50 francs. They will only be negotiable after the definite constitution of the society. The negotiation can only take place by transfer on the register of the society; and the by-laws may give either to the executive council or to the general assembly the right to oppose the transfer.

ART. 51. The by-laws will determine a sum below which the capital may not be reduced by the withdrawals authorized by article 48. The sum shall not be less than one-tenth the capital of the society. The society will be definitely constituted only after the payment of the tenth.

ART. 52. Each member shall be able to retire from the society whenever he may think proper, except by contrary agreement, and except as provided by the first paragraph of the preceding article. It may be stipulated that the general assembly shall have the right to decide, by the majority necessary for the modification of the by-laws, that one or more members shall cease to form part of the society.

Members who cease to form part of the society, either by their will or by the decision of the general assembly, will remain bound to the society and to third parties, during five years, for all the obligations existing at the time of their withdrawal.

ART. 53. The society, whatever may be its form, shall appear in court by its officers.

ART. 54. The society will not be dissolved by the death, withdrawal, suspension, failure, or bankruptcy of one of the members; it will continue in full force between the other members.

UNITED KINGDOM.

ANNO VICESIMO QUINTO & VICESIMO SEXTO VICTORIÆ REGINÆ.

CAP. LXXXVII.—An act to consolidate and amend the laws relating to industrial and provident societies.—7th August, 1862.

Whereas by the industrial and provident societies act, 1852, it is enacted, that it shall be lawful for any number of persons to establish a society under the provisions thereof and of the therein-recited act, for the purpose of raising by voluntary subscriptions of the members thereof a fund for attaining any purpose or object for the time being authorized by the laws in force with respect to friendly societies or by the said recited act, by carrying on or exercising in common any labor, trade, or handicraft, or several labors, trades, or handicrafts, except the working of mines, minerals, or quarries beyond the limits of the United Kingdom of Great Britain and Ireland, and also except the business of banking, whether in the said United Kingdom or elsewhere, and that the said act shall apply to all societies already established for any of the purposes herein mentioned, so soon as they shall conform to the provisions hereof; and whereas, by an act passed in the seventeenth and eighteenth years of her present Majesty, chapter twenty-five, various provisions were made for the better enabling legal proceedings to be carried on in any matter concerning the societies formed under the said act of 1852; and whereas the last-mentioned act was amended by an act passed in the first session of the nineteenth and twentieth years of her present Majesty, chapter forty; and whereas various societies have been formed and are now carrying on business under the provisions of the said recited acts, and it is desirable to consolidate and amend the laws relating to such societies: Be it therefore enacted by the Queen's most excellent Majesty, by and with the advice and consent of the Lords spiritual and temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

1. The industrial and provident societies act, 1852, and the said recited acts for the amendment thereof, are hereby repealed from the passing of this act.

2. All societies registered under the industrial and provident societies act, 1852, shall be entitled to obtain a certificate of registration on application to the registrar of friendly societies, and for which certificate no fee shall be payable to the registrar.

3. Any number of persons, not being less than seven, may establish a society under this act for the purpose of carrying on any labor, trade, or handicraft, whether wholesale or retail, except the working of mines or quarries, and except the business of banking, and of applying the profits for any purposes allowed by the friendly societies acts, or otherwise permitted by law.

4. The rules of every such society shall contain provisions in respect of the several matters mentioned in the schedule annexed to this act.

5. Two copies of the rules shall be forwarded to the registrar of friendly societies in England, Scotland, or Ireland, according to the place where the office of the society is situate, and shall be dealt with by him in the manner provided by the friendly societies act, 1855; antl he shall thereupon give his certificate of registration, and such certificate shall in all cases be conclusive evidence that the society has been duly registered, and thereupon the members of such society shall become a body corporate, by the name therein described, having a perpetual succession and a common seal, with power to hold lands and buildings, with limited liability.

6. The certificate of registration shall vest in the society all the property that may at the time be vested in any person in trust for the society; and all legal proceedings then pending by or against any such trustee or other officer on account of the society may be prosecuted by or against the society in its registered name without abatement.

7. A copy of the rules shall be delivered by the society to every person, on demand, on payment of the sum not exceeding one shilling.

8. No society shall be registered under a name identical with that by which any other existing society has been registered, or so nearly resembling such name as to be likely to deceive the members or the public, and the word "limited" shall be the last word in the name of every society registered under this act.

9. No member shall be entitled, in a society registered under this act, to hold or claim any interest exceeding the sum of two hundred pounds.

10. Every society registered under this act shall paint or affix, and shall keep painted or affixed, its name on the outside of every office or place in which the business of the society is carried on, in conspicuous position, in letters easily legible, and shall have its name engraven in legible characters on its seal, and shall have its name mentioned in legi-

ble characters in all notices, advertisements, and other official publications of such society, and in all bills of exchange, promissory notes, indorsements, checks, and orders for money or goods purporting to be signed by or on behalf of such company, and in all bills of parcels, invoices, receipts, and letters of credit of the society.

11. If any society under this act does not paint or affix, and keep painted or affixed, its name in manner directed by this act, it shall be liable to a penalty not exceeding five pounds for not so painting or affixing its name, and for every day during which such name is not so kept painted or affixed; and if any officer of such society or any person on its behalf uses any seal purporting to be a seal of the society whereon its name is not so engraven as aforesaid, or issues or authorizes the issue of any notice, advertisement, or other official publication of such society, or signs or authorizes to be signed on behalf of such society any bill of exchange, promissory note, indorsement, check, order for money or goods, or issues or authorizes to be issued any bill of parcels, invoice, receipt, or letter of credit of the society, wherein its name is not mentioned in manner aforesaid, he shall be liable to a penalty of fifty pounds, and shall further be personally liable to the holder of any such bill of exchange, promissory note, check, or order for money or goods, for the amount thereof, unless the same is duly paid by the society.

12. Every society under this act shall have a registered office to which all communications and notices may be addressed. If any society registered under this act carries on business without having such an office, it shall incur a penalty not exceeding five pounds for every day during which business is so carried on.

13. Notice of the situation of such registered office, and of any change therein, shall be given to the registrar, and recorded by him: until such notice is given, the society shall not be deemed to have complied with the provisions of this act.

14. The rules of every society registered under this act shall bind the society, and the members thereof, to the same extent as if each member had subscribed his name and affixed his seal thereto, and there were in such rules contained a covenant on the part of himself, his heirs, executors, and administrators, to conform to such rules subject to the provisions of this act; and all moneys payable by any member of this society in pursuance of such rules shall be deemed to be a debt due from such member of the society.

15. The provisions of the friendly societies acts shall apply to societies registered under this act in the following particulars:

Exemption from stamp duties and income tax:

Settlements of disputes by arbitration or justices;

Compensation to members unjustly excluded:

Powers of justices or county courts in case of fraud:

Jurisdiction of the registrar.

16. The provisions of the friendly societies act, 1854, whereby a mem-

ber of any society registered thereunder is allowed to nominate any person to whom his investment to such society shall be paid, shall extend, in the case of societies registered under this act, to allow any member thereof to nominate any person into whose name his interest in such society at his decease shall be transferred; provided, nevertheless, that any such society may, in lieu of making such transfer, elect to pay to any person so nominated the full value of such interest.

17. Any society registered under this act may be wound up either by the court or voluntarily, in the same manner and under the same circumstances under and in which any company may be wound up under any acts or act for the time being in force for winding up companies; and all the provisions of such acts or act with respect to winding up shall apply to such society, with this exception, that the court having jurisdiction in the winding up shall be the county court of the district in which the office of the society is situated.

18. In case of the dissolution of any such society, such society shall nevertheless be considered as subsisting, and be in all respects subject to the provisions of this act, so long and so far as any matters relating to the same remain unsettled, to the intent that such society may do all things necessary to the winding up of the concerns thereof, and that it may be sued and sue under the provisions of this act, in respect of all matters relating to such society.

19. The provisions of the joint-stock companies acts as to bills of exchange and the admissibility of the register of shares in evidence shall apply to all societies registered under this act.

20. In the event of a society registered under this act being wound up, every present and past member of such society shall be liable to contribute to the assets of the society to an amount sufficient for payment of the debts and liabilities of the society, and the costs, charges, and expenses of the winding up, and for the payment of such sums as may be required for the adjustment of the rights of the contributories among themselves, with the qualifications following—that is to say:

1. No past member shall be liable to contribute to the assets of the society if he has ceased to be a member for a period of one year or upwards prior to the commencement of the winding up.

2. No past member shall be liable to contribute in respect of any debt or liability of the society contracted after the time at which he ceased to be a member.

3. No past member shall be liable to contribute to the assets of the society unless it appears to the court that the existing members are unable to satisfy the contributions required to be made by them in order to satisfy all just demands upon such society.

4. No contribution shall be required from any member exceeding the amount (if any) unpaid on the shares in respect of which he is liable as a past or present member.

21. Any society registered under this act may be constituted a company

under the companies acts, by conforming to the provisions set forth in such act, and thereupon shall cease to retain its registration under this act.

22. Every person or member having an interest in the funds of any society registered under this act may inspect the books and the names of the members at all reasonable hours at the office of the society.

23. The sheriff in Scotland shall, within his county, have the like jurisdiction as is hereby given to the judge of the county court in any matter arising under this act.

24. A general statement of the funds and effects of any society registered under this act shall be transmitted to the registrar once in every year, and shall exhibit fully the assets and liabilities of the society, and shall be prepared and made out within such period, and in such form, and shall comprise such particulars as the registrar shall from time to time require; and the registrar shall have authority to require such evidence as he may think expedient of all matters required to be done, and of all documents required to be transmitted to him under this act; and every member of or any depositor in any such society shall be entitled to receive, on application to the treasurer or secretary of that society, a copy of such statement, without making any payment for the same.

25. All penalties imposed by this act, or by the rules of any society registered under this act, may be recovered in a summary manner before two justices, as directed by an act passed in the eleventh and twelfth years of the reign of her present Majesty Queen Victoria, chapter forty-three, entitled, "An act to facilitate the performance of the duties of justices of the peace out of sessions within England and Wales, with respect to summary convictions and orders."

26. This act may be cited as "The industrial and provident societies act, 1862."

SCHEDULE OF MATTERS TO BE PROVIDED FOR IN THE RULES.

1. Object and name and place of office of the society, which must, in all cases, be registered as one of limited liability.
2. Terms of admission of members.
3. Mode of holding meetings and right of voting, and of making or altering rules.
4. Determination whether the shares shall be transferable; and in case it be determined that the shares shall be transferable, provision for the form of transfer and registration of shares and for the consent of the committee of management and confirmation by the general meeting of the society; and in case shares shall not be transferable, provision for paying to members balance due to them on withdrawing from the society.
5. Provision for the audit of accounts.
6. Power to invest part of capital in another society; provided that no such investment be made in any other society not registered under this act, or the joint stock companies act, as a society or company with limited liability.

7. Power and mode of withdrawing from the society, and provisions for the claims of executors, administrators, or assigns of members.

8. Mode of application of profits.

9. Appointment of managers and other officers, and their respective powers and remuneration.

PROVISION AUTHORIZING INDUSTRIAL PARTNERSHIPS.

Extract from the "act to amend the law of partnership," 28 and 29 Victoria, chap. 86, (July 5, 1865:)

"No contract for the remuneration of a servant or agent of any person engaged in any trade, or undertaking by a share of the profits of such trade or undertaking, shall, of itself, render such servant or agent responsible as a partner therein, nor give him the rights of a partner."

APPENDIX F.

THE MANUFACTURE AND WEAR OF RAILS.

By Christer Peter Sandberg, *Associate of the Institute of Civil Engineers.*

A *paper* (No. 1,196,) *read before the Royal Society of Civil Engineers in London, March* 3, 1868, *by C. P. Sandberg, esq.; Charles Hutton Gregory, president, in the chair.*

In these times, when communication between different places is carried on mainly by the system of railways, it becomes important to determine the best mode of manufacturing railway bars, so as to obtain the greatest amount of wear at the least possible cost. As this question is one of increasing interest, the author has thought it might be profitable to communicate to the members of the Institution of Civil Engineers the experience he has gained during the last six or seven years, while engaged in superintending the supply of rails to the three Scandinavian countries, Sweden, Norway, and Denmark.

The paper will be divided into three parts. First, as to the best method of manufacturing rails out of common iron, and as to the time they will last. Secondly, as to the disposal of the iron rails when they are worn out; and thirdly, as to whether iron or steel, or a combination of the two materials, is the most economical to use for rails.

BEST METHOD OF MANUFACTURING RAILS FROM COMMON IRON.

The mode of manufacturing rails for Sweden, as carried out in Wales between the years 1856 to 1860, consisted in hammering the pile for the top slab after the first welding heat, and in rolling it after the second heat. It was supposed that hammering would produce a superior weld and a harder wearing surface than could be obtained by rolling alone. This method was, however, gradually superseded at other works in England and in Wales, during the period referred to, by rolling only. Hammering the slab, after the first welding heat, entailed an additional charge of 20*s.* per ton; it therefore became the duty of the Swedish government to determine, by practical trials, whether the value of the finished rail was correspondingly increased. With this object in view, several rails were rolled, and arrangements were made for putting them down in such situations, on some of the English lines, as would expose them to severe wear. The experiments further aimed at discovering, if possible, how long the rails manufactured at the Cwm Avon Works, in South Wales, and imported into Sweden, would resist the traffic in that country. Five different kinds of "piles" were employed; twenty rails, of a flange section, 4½ inches deep, and weighing 62 pounds per yard, being rolled of each particular sort. The mode of manufacture was as follows:

The rails marked T were made from a pile formed of No. 2, or w
iron, for the top and bottom, the rest of the pile being of No. 1 pu
bar iron. The top slab and the squares next to it were made fr
hammered bloom of ordinary puddled iron, and filled in at the m
with crop ends from top slabs, and other pieces of No. 2 iron.

The rails marked Y were made from a pile of the same compositi
that of the T rails, with the difference that the pile for the top slab
sisted of puddled bars, without any welded iron pieces or crop ends l
introduced in the middle of the pile.

The pile for the rails marked H was composed of a top slab made
puddled bars, hammered after the first heat, and rolled after the se
heat, similar to the rails marked Y, the iron for the flange consisti
four pieces instead of eight.

The pile for the rails marked E was exactly similar to that for the
marked H, excepting that the pile for the top slabs was rolled afte
first heat, as well as after the second heat. This difference in the r
of manufacture was adopted in order to discover whether, in this con
iron, hammering improved the rail to a corresponding extent. Ins
of No. 2 iron, puddled bars were chiefly used for the squares near
slab, and for the foot of the rail.

The pile for the rails marked N consisted of puddled bars without
top slab. All the piles passed through the rolling successfully witl
exception of the N rails, some of which showed cracks, owing t
inferior quality of the puddled bar.

The London and Northwestern Railway Company, being interest
the solution of this problem, allowed experiments to be made on
line, so far as the wear of these experimental rails was concerned.
experiments were carried out at Camden Town Station, where the
could be better and more thoroughly tried than elsewhere. First
account of the enormous traffic which obtains at that spot; seco
from the constant shunting, and, thirdly, owing to the grinding a
of the engine wheels in starting the trains. The result of these ex
ments is shown in a series of tables, drawn up by Mr. H. Woodh
superintendent of permanent way. (See Appendix.)

The following table shows the number of tons passed over each ex
mental rail before it was crushed, and also before the rails were taken

Mark of rail.	Crushed.	Worn
	Tons.	*T*
T	3, 680, 000	5, (
Y	4, 140, 000	5, [illegible]
H	3, 220, 000	5, (
E	6, 900, 000	8, [illegible]
N	3, 220, 000	5, [illegible]

Another table, calculated from the preceding one, shows how long
rails will last, supposing them to be passed over by 3,000 trains ye

each train being composed of an engine weighing 30 tons, and of 20 wagons of 10 tons each, or a gross load of 230 tons.

From these tables it was ascertained that the five different descriptions of rails were on the average crushed in six years, and worn out in nine years, thus:

T.		Y.		H.		E.		N.	
Crushed.	Worn out.	Crushed.	Worn out.	Crushed.	Worn out.	Crushed.	Worn out.	Crushed.	Worn out.
Years.	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*	*Years.*
5	7	6	7	5	7	10	13	5	8

As the object of these experiments was chiefly to ascertain the difference between a rolled and a hammered slab, both made from inferior iron, E representing the former and H the latter, those rails were placed so as to compare their relative resistance to wear; and the result shows the E rail with the rolled slab to be superior at each place where the rails were tested.

Among the other descriptions of rails the N section endured the longest, although it had no top slab of No. 2 iron.

The conclusion is thus arrived at that hammering after the first welding heat, for this particular kind of iron, does not improve the endurance of the rails, but that the simplest mode of manufacture has also the material advantage of being the best. These trials at the same time establish the fact that it is not the wear or the diminished sectional area caused by abrasion which produces the unsatisfactory results in the endurance of iron rails, but the lamination caused by imperfect welding. This explains the great difference in the result between the wear of rails made in exactly the same way, the welding in the one case being perfect, whilst in the other it has been very imperfect.

The results obtained at the Camden Town station, however, are not applicable to the circumstances and conditions of the wear of rails which occurs under ordinary traffic, but rather to exceptional situations, where the wear is occasioned principally by the frequent use of the brakes and by continual shunting, in a much higher degree than at any other point of the line. These results may also be attributed, in part, to the great weight of the locomotives in proportion to the weight of this particular section of rail.

Rails of the same dimensions and of similar quality of iron to those marked E have been tried on the Great Northern railway, and have lasted during the passage of about 65,000 trains of a total aggregate weight of 13,000,000 tons, one-fourth part of this traffic being at a speed of about 40 English miles per hour, and the remaining three-fourths of 25 miles an hour.

These experiments confirm the rule laid down in Mr. R. Price Williams's paper "On the Maintenance of Permanent Way," viz., that the endurance of rails may be measured by the product of the speed an of the passing weight. The trial rails on the Great Northern railwa may thus be said to have borne 276,000,000 tons at a speed of one mi per hour. The endurance of the rails tried at Camden Town, und such unusual conditions, is much less, and may be represented b 120,000,000 tons at a speed of one mile per hour.

Another method of arriving at a judgment as to the endurance these rails on the Swedish state lines, is found in the renewals whic have been already made on those railways. The present experienc extends over a period of nine years on portions of the most severel worked lines, namely, at Gottenburg and Malmo, and also during period of six years on the whole system. The renewals on the main lin have been in an increasing proportion, being in one case 30 or 40 pe cent. higher than in the preceding year; and a mean calculation give the probable result that, taking the last renewals of the rails laid dow on the construction of the lines at about 18 years from the commence ment, the average life of the rails will be 15 years.

The weight which has passed over the rails during these 15 year judging from the reports contained in the annual accounts of the gov ernment railway administration as to the traffic returns of all the stat lines during the years 1862 to 1865, may be assumed to be a yearl increase, in the gross load, of only 15 per cent. per mile after the yea 1865. The yearly increase, however, on the line nearest Gottenbur since 1862, of transported goods, has amounted to 30 per cent., and nea Malmo to 18 per cent. Further, supposing the same proportion to exis between the gross and the net loads for the year 1865, it may be take at about 6,000,000 tons, a quantity which compares with the result obtained on the English lines, giving for the life of the best of th three first sort of rails the same average life as that of the E rails. Thi confirms the correctness of the theory that the life of rails is measure by the product of the weight and the speed.

The rails used on the Swedish lines are mostly of the E or rolled clas before mentioned. Those tried on the Great Northern line were also o that kind of manufacture, but of a heavier section. The speed at whic the load was carried over the experimental rails on the Great Norther railway was much higher than on the Swedish lines, being in the pro portion of 20 on the Great Northern to 16 miles average speed on th Swedish railways.

The conclusions the author has arrived at are, that no rule can b laid down for the manufacture of rails that will apply to every manufa turing district; but that in the case of Welsh iron, to which he has mo particularly referred, it has been proved that the best method of manu facturing the rail is that now most commonly practiced, viz: rolling th iron into bars, piling these, and repeated rolling to the finished ra without hammering. The author assumes the prejudicial result fro hammering to be owing to the large amount of sulphur in the Wels ton. Where the iron contains more phosphorus and less sulphur, as, for instance, in the Cleveland, Belgian, and French iron districts, hammering has proved beneficial, and rails have been made direct from puddled bars without the intermediate process of piling, this being, in fact, the method generally adopted in those places, and being found to answer best.

These experiments seem to indicate that 220,000,000 tons may be carried over rails, of the section and make referred to, at a speed of one mile per hour; so that any railway company, knowing the load which yearly passes over their line and the speed, may, by multiplying the one into the other, and dividing this product by 220, ascertain the life of iron rails in years.

DISPOSAL OF IRON RAILS WHEN WORN OUT.

As to the disposal of the rails when worn out, and as to the possibility of rerolling old rails with advantage by companies far situated from the seat of manufacture, such as the British colonies, the countries around the Mediterranean or the Baltic, the author thinks that for railways near the seat of rail manufacture, the best way will be to continue to sell the old rails to the rail mills. For other countries, situated like Sweden for instance, it becomes important to ascertain whether it would not be more advantageous to reroll them.

The increasing traffic, the augmented speed, together with the heavier engines now found desirable, have all a tendency to more severe wear, and to render necessary more frequent renewals of the rails. These renewals are executed with more and more difficulty, as the greater number of trains limits the time at disposal, whilst the stoppage of the traffic thus occasioned often results in accidents. These considerations, together with the recurring expenses of renewals, have conduced to the employment of a more durable material for rails, as steel, which is already much used. The new rails have been manufactured either entirely of steel, or iron rails have had steel tops added to them.

In the case of steel-top rails the head has either been entirely formed of steel, or else the upper surface only has been covered with a thinner or thicker top slab, say half an inch thick in the rail. The top slab has been joined according to the different methods used for forming the pile, so that it has been either lying flat over the wearing part of the rail head, or it has spanned the mass of iron with its exterior edges, thus fixing the steel without reference to the weld; it has, in fact, been partly mechanically fastened to it. The mode of making the pile at several places where old rails have been used instead of puddled bars, is shown in the plans, Figs. A, B, and C.[1] The pile used at Dowlais for 120 tons of steel-headed rails for the Swedish government railways in September last is shown in Plan B, and the one used at Hörde, in Germany, Plan A, all for the manufacture of steel-headed rails.

[1] These illustrations are omitted.

The use of steel rails has much increased in England, and many railway companies are adopting them as fast as their financial circumstances will allow.

The existence of a cheap raw material in the shape of old rails, and rerolling them together with Bessemer steel tops, affords an opening for carrying out the manufacture of rails profitably for railway companies far removed from the seat of manufacture, even when exposed to foreign competition. If such rerolling were carried out in Sweden, instead of selling the worn out iron rails in England, the expense of freight to and fro would be saved, which may be reckoned at £2 per ton. The necessary cost of coal would not increase the price of rails more than about 10*s*. per ton for rerolling rails in Sweden.

The question is thus reduced to an inquiry whether the increased cost of manufacture, due to the smallness of the quantity to be made, would amount to, or exceed, the remaining part of the difference of the freight, £1 10*s*. per ton. If so, it would then be of no use to attempt the establishment of a manufacture of rails, either by the government in connection with other workshops for the repair and renewal of railway materials of other kinds, such as engines, axles, wheels, etc., or by private capitalists.

An estimate has been made, the particulars of which will be found in the appendix, of the cost of manufacturing rails in Sweden, composed of Swedish Bessemer steel for the head, No. 2 iron for the flange or foot, the remainder of the pile being of old iron rails. The rails are of the Vignoles section, weighing 66 pounds per yard.

From these calculations it is shown:

1. That according to plan A, with the whole head of Bessemer steel, the cost per ton on an annual make of 10,000 tons is £8 12*s*. 1*d*.; and secondly, according to plan B, with the top or wearing surface of the rail only of Bessemer steel, the cost per ton on an annual make of 6,000 tons is £8 6*s*. 8*d*.

It therefore follows that the difference between these amounts and £10, the lowest price at which such rails can be imported into Sweden from England, viz. £1 7*s*. 11*d*., by plan A, and £1 13*s*. 4*d*., by plan B, respectively represents the net profit to be derived from the transfer of rerolling operations to Sweden. In other words, providing this calculation is not too low, this represents in the first case 16 per cent., and in the second case about 20 per cent. of the whole cost of production.

In England, the London and North Western, and the Great Western railway companies are rerolling the worn-out rails at their own workshops, where the repairs of other railway materials are also executed, and at both these places Bessemer steel has been used for the head of the rails. The other English railway companies are selling their worn-out rails, as there is sufficient competition to prevent them being sold below the market price.

There is no railway company in France which has works for rerolling the worn-out rails; neither is there any in Belgium or in Prussia, the rails being sold to the private rail mills in the respective countries, and being used in connection with other iron for rail manufacture.

In Austria, the state railways are carrying out the rerolling of rails at the state's own workshops at Grätz, while the making of axles and tires is performed at the state's workshop at Neuberg.

In Russia, the rolling of the rails is executed at a workshop near St. Petersburg, altered for the purpose by a private company. The side irons and top slabs are of manufacture, but sometimes the top slabs are made at home from scrap iron. The English fuel is used. The Petersburg and Moscow railway receive in exchange for their old rails three-quarters of their weight in new rails, and pay a certain sum, according to the specification, for each weight of rails received. By the other great Russian railway the old rails were at first sent to England, but for some time a private iron-work near Petersburg, called Orgareff, has carried on the rerolling on the following conditions: The railway company finds one ton of old rails, and receives one ton of new rails, and pays £7 14*s.* per ton, but has then a guarantee for five years.

Having stated the case of Sweden as an example, other railways in similar circumstances in the British colonies and in the countries round the Mediterranean may be similarly dealt with. The special conditions being different in each case, make it difficult, if not impossible, to give an example that would suit every case. The principle laid down may be useful as a guide as to what is to be done with the rails when worn out.

THE MOST ECONOMICAL MATERIAL TO BE EMPLOYED FOR RAILS.

In the first part of the third division of the paper, as to the best and most economical material to be employed for rails, the particular circumstances affecting Sweden are considered.

From these facts the following conclusions are drawn:

First. That solid Bessemer steel rails, which are not likely to be manufactured at a cheaper price in Sweden than in England, or £13 per ton, are too dear to use on the Swedish railways.

Second. That the Swedish puddled steel rails, which cannot be manufactured for less than £12 per ton, are also too dear for the railways, even if they should last twice as long as iron rails of English make.

Third. That steel top rails at £10 per ton are the cheapest for the Swedish railways, being cheaper than rails of Welsh iron at £8 per ton; and that it will thus become the duty of the railways administration to procure such a steel-top rail, not only for the new lines about to be constructed, but also for the maintenance of the existing lines.

In arriving at these conclusions, it must be admitted that, up to the present time, the experience of the durability of the different kinds of rails has not been sufficient to render the conclusions drawn thoroughly reliable.

Further, this experience of the durability of the steel-top rail and the solid steel rail may not agree with individual cases of failure whe in consequence of defective welding, the steel head has come off, or wh the solid steel rail has broken. At the same time, it must be admitt that the process of steel making, and of welding the steel slats to rail, is, as yet, in its infancy, so that great progress may yet be expect The principle ought not to be condemned because of individual failu

Assuming that, under a very heavy traffic, common iron rails last f years, steel-top rails 15 years, and solid steel rails 30 years, and that iron rails cost £7 per ton, steel-top rails £10 per ton, and solid steel ra £15 per ton, and that the old steel-top and iron rails are valued at per ton, and the old solid steel at £8 per ton, then with a rail section of pounds per yard, 250 tons of rails will be required for one mile of dou line, and the cost of laying the rails may be estimated at £1 per t The following example, as to iron rails lasting five years, will serve explain the way in which the subsequent annuity tables have been c culated:

Two hundred and fifty tons, at £7 per ton £1,
Cost of laying down...

Total.. 2,
Which sum, at the end of five years, at five per cent. compound interest, becomes.. 2,
The difference between this sum (£2,552) and the value of the old rails (250 tons at £4 per ton=£1,000) is..................... 1,

The annuity required to recoup this latter sum in five years is £28

For one English mile of double line, interest being reckoned at 5 cent., and steel-top rails being calculated to last three times and so steel rails six times as long as iron rails:

Annuity table.—No. 1.

When iron rails last—	The annuity would be for—		
	Iron rails.	Steel-top rails.	Solid s rails
2 years	£587	£395	
3 ..do	417	307	
4 ..do	332	247	
5 ..do	280	218	
10..do	179	163	
15..do	134	148	
20..do	130	140	

It may be objected that the prices quoted for solid steel rails in the foregoing calculations are too high. Rails of this kind have been sold in some places as low as £12 per ton, but for the very best quality the present price is £15 per ton, and it is only from these that the experience has been gained as to their enduring six times as long as iron rails. However, table No. 2 has been calculated for the different kinds and periods at the following prices, viz: iron rails at £6, steel-top rails at £9, and solid steel rails at £12 per ton, crediting the old iron and steel-top rails at £3 per ton, and the solid steel rails at £5 per ton.

Annuity table.—No. 2.

When iron rails last—	The annuity would be for—		
	Iron rails.	Steel-top rails.	Solid steel rails.
2 years	£574	£382	£288
3 ..do	404	283	233
4 ..do	319	234	230
5 ..do	268	206	174
10..do	166	149	168
15..do	133	136	163
20..do	117	126	150

This table shows that in all cases, except the last, solid steel rails are the cheapest.

The amount of traffic must, therefore, decide which material it is the most economical to use for the maintenance of the permanent way. For all railways where ordinary iron rails are worn out in five years, or in a shorter time, solid steel rails are the most economical at the price quoted in table No. 1.

When ordinary iron rails last over five and up to ten years, steel-top rails would be the cheapest; iron rails in these cases being clearly proved to be the most expensive, although the cheapest where they last from 15 to 20 years.

As these calculations are founded on the short experience gained up to the present time in reference to the relative endurance of the different kinds of rails, a still longer trial is desirable.

The foregoing tables refer to rails of the Vignoles section. Table No. 3 has been made up for the ordinary double-headed rails, according to the prices stated, the considerations being the same as in table No. 2, except that the chairs have been taken into account. Allowance has been made for 140 tons of new chairs per mile, at £5 per ton, credit being given for the value of the old chairs at £2 10s. per ton. It may be observed that steel-headed rails are here estimated to last four times, and solid steel rails eight times as long as ordinary iron rails; that is, making allowance for the use of both faces:

Annuity table.—No. 3.

When iron rails last—	The annuity would be for—		
	Iron rails.	Steel-top rails.	Solid steel rails.
2 years	£780	£379	£296
3 ..do	551	291	249
4 ..do	436	244	228
5 ..do	366	233	217
10..do	229	177	199
15..do	183	166	....
20..do	163	162	....

This table indicates that the iron rails are in no instance the cheapest but, on the contrary, that when iron rails last only up to five years, solid steel have the advantage; and where the iron rails have a longer duration, then steel-headed rails are the most economical.

It is to be hoped that railway companies having a heavy traffic will give different sorts of rails great attent on, and submit them to trials on a large scale; and, on the other hand, that the steel works will try their utmost to manufacture solid steel, as well as steel-headed, rails of the best sort for the purpose, so that this important question may soon be decided.

Before concluding, another fact must be taken into consideration, viz. the safety of the three different materials, in regard to high speeds, severe climate, &c. This seems of late to have engaged the attention of the railway world, and has been discussed, not only in England but on the continent. The Swedish government, having undertaken the construction of railways in that country, appointed a committee, composed of many eminent men, to consider it. This committee found it necessary to make experiments with different materials, from England as well as Sweden, and, after five years' consideration and study, the report has just been published by Professor Styffe, the director of the Government School of Mines at Stockholm.

From this report it appears that the tenacity and elongation of different materials are influenced by the amount of carbon.

The tenacity influenced by carbon.

Description of materials.	Carbon per. cent.	Elongation per. cent.
3essemer steel and Uchartius steel	1.85 to 1.0	0.3 to 0.9
teel	0.69 to 0.61	1.2 to 2.1
steel or iron	0.42 to 0.33	1.9 to 4
	Specific gravity.	
lake ores, (rich in phosphorus)		0.8 to 3.4
Dudley, (rich in slag and phosphorus)	7.5	2.5 to 4.2
Midlesboro'-on-Tees	7.65	3.4 to 5.9
ron from Sweden and Low Moor	7.77 to 7.80	6.1 to 9.5
ron made in refining furnace	7.84	7.3 to 7.8

The absolute strength influenced by carbon.

Description.	Carbon per cent.	Weight in lbs. per sq. inch when broken.
harcoal puddled iron	0.8	113,381
harcoal puddled iron	0.7	84,265
3essemer steel	0.8	90,921
3essemer steel	0.55	86,941
Bessemer steel	0.50	71,090
Bessemer iron	0.20	48,102
puddled iron	0.70	83,441
puddled iron	0.70	83,716
ron from another work	0.6	73,492
iron from another work	0.6	82,344
iron from another work	0.5	78,432
iron from another work	0.7	86,049

se tables show that the hardest material has the greatest absolute ;th, both before and after permanent set has taken place, but it .e least ductility; on the other hand, a softer material shows the st tenacity or elongation, the Bessemer material giving the same 3 as that prepared from the same pig iron by puddling, refining or st-steel process.

he diagram illustrating these results, the percentage of carbon iosphorus is stated in nearly all cases. The limit for the amount)on seems to be for the Bessemer material 1.2 to 1.5 per centum. a larger amount the absolute strength, as well as the tenacity, has ound to decrease. When the amount of carbon does not exceed centum, and the material is not worked at too low a heat, the tion seems to be 16 per centum, or the same as for puddled iron ie same pig iron; and as such Bessemer material is not only much er, but also more solid or homogeneous than the puddled material, it deserves a decided preference for all railway purposes. The few cases of failures of rails by breaking may be accounted for as the result of too hard a material, not perfectly manufactured, having been made at the earlier period of the introduction of the process. The experience which has now been gained should certainly prevent any recurrence of this.

Iron and steel when tried for tensile strength under the influence of extreme temperatures, such as boiling water and at the freezing point of mercury, has led to the discovery, contrary to the general belief, that the tensile and absolute strength is greater during cold than during ordinary temperature; that is, iron or steel is stronger in winter than in summer. The reason why more breakages occur in winter than in summer is asserted to be due to the extreme cold affecting the elasticity of the supports, (sleepers,) and that elasticity in any way given to the rolling stock also favorably affects the resistance of the rails.

However, if the supports have the same elasticity in summer as in winter, as, for instance, would be the case with granite rock, then Professor Styffe asserts that the same rails, either of iron or of steel, can resist a heavier blow from a falling ball at the temperature of extreme cold than on a hot summer's day. Although the experiments have been conducted with the utmost care and skill that science and money can afford, it seems desirable that this theory should be proved on a larger scale than Professor Styffe has had an opportunity of doing, before it can be relied upon.

At a meeting of engineers, at Stockholm, in March, 1867, it was decided that Bessemer steel rails, made from charcoal pig iron, might, without risk, be used 10 per centum lighter than the English iron rails, and in Austria this has already been practiced with success by the engineer-in-chief, Wöhler.

It must, however, be observed, that the raw material used in both cases is charcoal pig iron of a superior quality as compared with that used in England for making Bessemer rails, which may be seen from the following analyses made by two eminent chemists:

Analyses of Swedish and English pig iron.

Bessemer Swedish pig iron, Fagersta Works. Analyzed by Kohlberg.		English Bessemer pig iron, Workington, Cumberland. Analyzed by John Percy.	
	Per cent.		*Per cent.*
Graphite	2.733	Carbon	2.993
Combined carbon	2.138	Silicon	3.080
Silicon	0.641	Manganese	0.079
Manganese	2.926	Sulphur	0.021
Sulphur	0.015	Phosphorus	0.021
Phosphorus	0.026		

These analyses show that the great difference between the two is the excess of silicon in the English, and of manganese in the Swedish pig iron; thus explaining why the one gives a better result than the other, although worked entirely without the addition of spiegeleisen.

If there be only 0.6 per cent. of carbon in the solid steel, and 0.3 per cent. in the steel for the steel head, the safety ought to be the same for all the three kinds, and this would not influence the former calculations as to which is the best and most economical material for rails.

Having watched the development of the Bessemer process in England, as well as on the continent, it seems to the author that by that process a good and pure raw material has the same advantage over an inferior one as in all other processes, and that a superior product cannot be obtained from an inferior raw material by that process any more than by others. In having mentioned Swedish material, as an example, it must not be supposed that it is wished to advocate the use of Swedish iron in this country, but simply to draw attention to the better material, as equally good charcoal iron can be supplied from Canada and India, both English colonies. It may also be remarked, that the author's endeavor has been to arrive at the truth irrespective of prejudice, and that he has no wish to be deemed an advocate for one kind of rail more than any other.

These observations determine the sense of the law. To speak properly, the legislature has wished, with regard to women, merely to sanction the pre-existing usages, and all shows that it had particularly in view the work people of factories, and those who exercise an *industrial profession*, properly so called.

It is within this limit, for the present at least, that I shall cause the law to be executed. It will be proper, therefore, that you abstain from all initiative in regard to female operatives hitherto not subject to the use of the *livret*, limiting yourselves to facilitating the procuring of this title by those who seek it voluntarily. It will only be after a certain time of experience that the administration will be able to fix its jurisprudence on this point.

There are certain professions which resist the adoption of the *livret* by claiming for those who exercise them the quality of *artists*. The law furnishes on this pretension a very simple means of solution by making the *livret* an electoral condition for the formation of the *consul des prud-hommes;* every individual who will have or who would like to take part in this election will be held to the obligation of the *livret*.

On the other hand, some have submitted at times to this obligation under pretext that they have no *patentes*—persons working directly for the consumers without intermediates. This is an error; these persons are not operatives; they are manufacturers, *patented* or not.

2.—OF THE GIVING OF THE LIVRETS.

In future the *livret* may not be obtained except on the production of an act certified by you conformably to the 2d paragraph of the 4th article of my ordinance. You will have, therefore, in the delivering of the *livrets* an essential part to perform on the subject of which I should enter into some details.

For a long time complaints have arisen about certain frauds which reduced the *livret* to a useless formality; these frauds arose from the facility with which the unfaithful workman could obtain a new *livret* after having left a previous one in the hands of an employer whom he had cheated. To put an end to this manœuvre the various projects presented to the chambers had surrounded the delivering of a *livret* with a long series of justifications in some respects fortified by the sanctity of an oath, by means of which it was hoped to assure at last the right of this title.

This was an error. For all that they were so minute, such precautions remained always impotent to prevent all the frauds, and they had the serious inconvenience of multiplying the formalities to the extent of becoming arrogant and vexatious for the mass of honest workmen. The new law proceeds by quite different means and infinitely more equitable and worthy. Instead of detailing a series of requisites, narrow and exclusive, it confides in the prudence of the administration as to the guarantees to be required; it supposes the good faith of the workman, and gives him every facility for obtaining a *livret;* but it punishes bad faith and visits with a correctional penalty manœuvres and false declarations, of which, moreover, it secures the evidence. It follows from this system that in the exceptional cases where the workman is not in a position to conform to the usual requirements, he can obtain a *livret* by a simple declaration signed by him, but at his risk and peril, and under the sanction of article 13 of the law of 22d of June, *which should be read to him beforehand.* Such is the provision of article 3 of the decree of the 30th of April, to which I invite you to refer each time that you may have to make application of it. In prescribing the reading of the penal text, the decree has sought to prevent a provision altogether benevolent toward the workman from becoming a snare for his inexperience. This formality is therefore an act the omission of which would involve your conscience and your responsibility.

You will remark that the provision which I have just mentioned is in nowise intended to set aside the conditions and guarantees hitherto required. It will only be under rare circumstances that it will be necessary to rest on the simple declaration of the candidate. But in ordinary cases you will have to require of the workman who solicits the certificate required by article 4 of my ordinance the proof of his identity and of his industrial position. This last proof will be given in future before you; it consists in general of the production of a discharge from apprenticeship, of certificates of labor given either by the former master or by the one who desires to employ the candidate, or, in short, of other similar documents.

Supposing the seeker to produce proofs of this nature or to demand the benefit of article 3 of the decree of the 30th of April, it will remain for you to fulfil his demand. I have had printed a form of certificate which it will be your duty to deliver, and copies will be furnished to you *provisionally* by my prefecture. This will be filled out by the commissioner of police of the *place of residence of the workman.* As I have said, it will be indiscriminately required of all workmen who demand a *livret*, be he even a native of Paris. As to the documents of proof and the certificates of labor, they will continue to be legalized by the commissioner of the place of delivery, and they will be presented to the functionary who receives the request for the *livret* and who gives the certificate.

3.—Registration at the prefecture of livrets obtained in the departments.

Article 2 of the decree enacts that there will be kept in each commune (at the prefecture of police for the department of the Seine) a register on which will be recorded at the time of their delivery the *livrets* and visas of travelling. This is a measure which interests the good direction of the service; but it would remain ineffectual in a centre like Paris if it limited itself to the recording of *livrets* obtained at the prefecture of police; also by the terms of a very old provision, reproduced in article 6 of my ordinance, the *livrets* delivered in the provinces must be equally registered at my office before they can be made use of in the province of the prefecture of police. This formality is shown by a special visa. I recommend you to see carefully to its execution.

4.—USE AND VISA OF THE LIVRETS.

The new regulation makes no change in the jurisprudence followed at Paris as to the use and visa of the *livrets*. You will have therefore merely to follow in this respect the established traditions which are specially mentioned in articles 6, 7, and 8 of my ordinance.

Thus the workman cannot be admitted into an establishment except on the presentation of a livret. He cannot leave this establishment except after having obtained a regular dismissal, and he must within the twenty-four hours of his leaving submit this dismissal to your visa. It is only after this formality that he can be received by a new employer under penalty of prosecution of the latter, except in the case that will be mentioned hereafter, of home workmen. On his part, the employer cannot receive a workman unless as the latter is furnished with a livret in proper condition. He visés this *livret* at the entry of the man, records it on his register, and submits it within the twenty-four hours to your own visa.

After such visa given by you, you are to address to me an abstract in the form of a printed bulletin, of which you will continue to demand from my office the blanks which you may require. The sending of this bulletin, neglected of late, must be recommenced. I attach a real importance to it. I shall take care that this measure be strictly executed, and I count on all your vigilance in this respect.

You will notice that the bulletin of which we speak should relate the advances with which the livret may be charged. Please recommend this detail to the attention of employers.

5.—DISTINCTION OF THE TWO CATEGORIES OF WORKMEN SUBJECT TO THE LIVRETS.

I come now to one of the most important provisions of the law, and one at which it is the more necessary to stop, as it is new and of a complex application.

Hitherto the majority of artisans working at home and known under the name of home workmen, *(ouvriers en chambre,)* have remained without the use of the *livret*. This was a deficiency to be filled up; but there arose difficulties of which the former laws failed of the solution. Of the home workmen, there is no hesitation as to those working for a single establishment, to which they are really attached. They should be subject to the *livret*. But others, working simultaneously for several employers—how can the ordinary obligations which the use of the *livret* entails be reconciled with such a situation? The legislature of 1854 has not allowed itself to be hindered by this objection. It has considered that the benefit of the *livret* consisted before all in its very existence.

Consequently, it has prescribed the employment of it indiscriminately for all workmen, dispensing, in favor of those working for several masters, with formalities incompatible with their position. The law distinguishes, therefore, two classes of workmen subject to the use of the *livret*, but with different obligations:

1. Those attached to a single establishment and employed only by it, whether they work in this establishment itself or outside.

2. Those working habitually for several establishments and employable by more than one master at the same time.

The first can only be admitted into a new establishment on proving their integrity by a dismissal or certificate of departure from their previous employer; the others are relieved of this formality, and obliged simply to have their *livret* viséd at the commencement by each employer who hires them *for the first time.* You will find these distinctions clearly defined in acts 7 and 9 of the decree of the 30th April.

By the terms of the second paragraph of the first article of the same decree, the *livret* must state to which category the workman belongs. Again, article 9 obliges the chief of the establishment who receives a workman to mention, as well on his register as on the *livret* of the said workman, in what capacity he employs him.

Thus the character or category of the workman is determined by the *visa of entry* which the employer of the two categories is obliged to enter on the *livret* at the time that he employs this workman; and since the obligations and rights of the workman and employer vary according to the category to which the former belongs, it is of the last importance to observe in the visas the fundamental distinction which has just been indicated.

To render this distinction more apparent, I have ordered forms of visas which I invite you to have adopted by the chiefs of establisments. They are as follows:

1.—*Visa of entry for the workman of the first category.*

"Admitted by me as workman attached to a single establishment.
PARIS, the ——— ———, 18—."
(Signature and residence of employer.)

2.—*Visa of entry for the workman of the second category.*

"Employed by me as workman, working habitually for several establishments.
PARIS, the ——— ———, 18—."
(Signature and residence of employer.)

3.—*For the dismissals or certificates of departure.*

"Discharged, free of obligations, the ——— ———.
PARIS, the ——— ———, 18—."
(Signature and residence of employer.)

You have already understood, gentlemen, that that which I have now said of the indication in the visas of the category to which the workman belongs, applies to the certificate which you have to deliver for the procuring of a *livret*.

Finally, it is evident that the workmen of one category can pass into the other with the same *livret*. This change is shown in full force by the visa of entry. But here there is a remark to make: if the workman pass from the first category into the second, he must in the first place prove the accomplishment of his engagements towards his last master, while he is held to no proof in order to pass from the second category to the first.

6.—Register to be kept by the chiefs of establishments.

The law of the 22d of June contains still another innovation, of which you will easily understand the importance: it prescribes to the chiefs of establishments the keeping of a special register, in which he shall enter the name and position of each workman whom he employs. Conformably to article eight of the imperial decree, and of the delegation contained in article ten of my ordinance, this register will be numbered and countersigned by you; but you will address to me for each countersigned register a bulletin, bearing an abstract of your minutes; printed copies of these bulletins will also be supplied to you from my prefecture.

You will open with each of your commissariates a register, in which you will enter the chiefs of establishments whose private registers you have countersigned.

These latter registers are not subject to any periodical visa; still they will be communicated to you upon requisition, without being removed from the establishments themselves. It has appeared to the council of state that this provision will sufficiently facilitate the exercise of your supervision.

7.—Penal sanction—execution of the law.

Having fixed all the points of this important regulation, the legislature has wished to insure the execution of its work by attaching a penal sanction. The penalties which it has ordered are moderate, in view of the nature of the things, but sufficient in the hands of a vigilant administration. Henceforth, every infraction, either of the law itself or of the legal regulations on the matter, *will constitute a punishable offence*. Thus a deficiency is filled up which compromised seriously the preceding legislation.

I have only, gentlemen, to appeal to your zeal and experience to insure the reorganization and regularity of a service which I consider among the most important. I have reason to believe that, by means of the influence which the confidence of your people gives you, you will succeed in general in the usual way in obviating offences and prosecutions. It is my desire; but when, thanks to your counsels and your benevolent directions, the law shall be known and understood, you will have to search attentively, and report to me the infractions which may be committed against these wise provisions. The multiplicity of our relations with the industrial population, the keeping of the register of the employers, the visa of the *livrets*, their usage as papers of surety, will be to you so many opportunities and means to exercise a control which ought not to permit any violation, if it is done with the perseverance which I expect from you.

After having excited your zeal and your ordinary devotion, I conclude, gentlemen, by making an appeal to your prudence. You have to make the application of delicate measures; some of them excite susceptibilities, which it is necessary to allay or avoid; others are new, and will permit, especially at first, a wise reserve; all require tact and moderation. I hope that under these circumstances you will know as usual how to ally, in a just measure, prudence to firmness, and that you will contribute powerfully to assure the success of a regulation which ought to be a new title for the government of the Emperor to the recognition of the country.

I beg you to acknowledge the receipt of this circular.

Receive, gentlemen, the assurance of my perfect consideration.

PIETRI,
The Prefect of Police.

By the Prefect:

A. DE LAULXURES,
The Secretary General.

APPENDIX H.

EVIDENCE GIVEN BY ABRAM S. HEWITT BEFORE THE TRADES UNION COMMISSION IN LONDON, IN 1867.

1, PARK PROSPECT, WESTMINSTER,
Tuesday, July 16, 1867.

Present: The Right Hon. Sir William Erle, the Right Hon. the Earl of Lichfield, Lord Elcho, M. P., Sir Daniel Gooch, Bart., M. P., Herman Merivale, esq., C. B., James Booth, esq., C. B., Thomas Hughes, esq., M. P., Frederic Harrison, esq., William Mathews, esq.

The Right Hon. Sir William Erle in the chair.

Mr. ABRAM S. HEWITT further examined.

By the CHAIRMAN:

Q. I think you propose to say something on the general conclusion at which you have arrived with reference to the subjects on which you have been examined here?—A. Yes; I propose to add, as the answer to a question which Mr. Mathews put to me, the conclusion which I intended to utter at the time, but which probably passed from my mind in consequence of some interruption. Mr. Mathews said to me, "Is there any other information with which you could furnish us which you think would be of use to this commission?" And my reply then was to this effect: "I am going back to America, and will then be very happy to collect the information and send it to the commissioners;" and I stated then "It is not a question of master or workman, but of the public welfare." Now to that question I desire to add this conclusion: "The general conclusion at which I have arrived is that the effort to produce commodities at the lowest possible cost, in Europe generally, has led to the employment of juvenile and female labor to an extent and in a manner not consistent with the laws of humanity and the best interests of society; that the employment of this kind of labor has had the effect to reduce the standard of wages generally, and, instead of adding to the resources of the family, has simply secured the labor of the entire family for the wages which would otherwise have been paid to the head of the family, if he alone had worked for wages. This system is a leading argument against free trade in countries where the men only work out of the household, and generally tends to reduce the condition of the laboring classes all over the world. The restraining acts now in force in England with regard to the employment of children is a step in the right direction, and if other countries, such as Belgium, France, and Germany, could be induced to co-operate, the condition of the laboring classes in Europe could be greatly improved, although the cost of particular commodities might be slightly increased. But the production of cheap goods may be secured at too great a sacrifice, if it be at the expense of the comfort and moral tone of the working classes; and this appears to be the point at which you have arrived in England, and against which there is an instinctive rebellion, both among the enlightened and the ignorant, manifesting itself among the latter in organizations at war with the fundamental principles of social order, such as trades union associations."

By Mr. MATHEWS:

Q. That is simply an extension of the answers, though embodying a little more matter, which you have given previously?—A. Yes, that is my idea.

By the EARL OF LICHFIELD:

Q. Are you aware whether trades unions have ever taken any steps to prevent the employment of children under a certain age?—A. I have no knowledge on that subject.

By the CHAIRMAN:

Q. I believe you have another matter which you desire to mention?—A. I desire to correct my testimony upon certain points. I testified that the eight hours law had been passed by the legislature of the State of New York, but had been vetoed by the governor. I was so informed at the time that I gave the testimony, but within two days after the testimony had been given I received information from home that the governor had signed the bill; so that all that portion of my testimony which is in commendation of the governor for his firmness in resisting that law is out of place; he has actually signed the bill, and received the thanks of the working men for having done so. This is the form, therefore, in which my testimony ought to stand: "I am advised that the governor of the State of New York has signed the bill making eight hours a legal day's work in the State of New York, and that it is now a law."

By Mr. MERIVALE:

Q. You have no objection to its standing as your deliberate opinion that trades unions in themselves, whether conducted moderately or immoderately, are absolutely "at war with the fundamental principles of social order?"—A. I speak of trades unions as I understand them. I can imagine that trades unions for another purpose would not be at war with the fundamental principles of social order. I refer to trades unions that undertake to lay down the conditions upon which labor shall be bought and sold in the market.

By Mr. BOOTH:

Q. Is it your opinion that the eight-hour law will be acted upon in the State of New York?—A. I am now prepared to give some testimony on that subject. The passage of the eight-hour law in Illinois was followed by a general strike of the workmen in Chicago for eight hours' labor with ten hours' pay. That failed, as a matter of course, and they have resumed work in Chicago at ten hours a day, or in some cases at eight hours a day with 20 per cent. deduction from the wages, making it an equivalent compensation for the time. In New York the workmen have not struck, but instead of that they held a convention in the city of Albany, which is the capital of the State, and in that convention, after a great deal of discussion, they resolved that after the 1st day of November next no member of a trades union would work more than eight hours per day for a day's labor, but that they would accept 20 per cent. deduction on the wages which they were receiving for ten hours; so that the question now is simply the question of working eight hours at an equivalent rate of wages to the rate received when they worked ten hours, and they have resolved to put that in force on the 1st day of November next.

Q. In what form does the act limit the day's labor to eight hours?—A. It simply declares that, in the absence of any provision to the contrary, a legal day's labor shall be eight hours; so that if I contract with a man for a day's work at any given sum he is bound to give me eight hours' labor for that sum, and I am bound to accept eight hours for that sum; but there is nothing in the law to prevent a contract for more hours and a different rate of wages. I have brought with me the resolutions which were adopted by this convention. I do not know that the commission wish to hear them, but they are brief, and I brought them for the purpose of showing in what form these matters are coming up in our country. I testified before that I thought that trades unions had not reached so great a degree of development in America as here. I still think that in details they are less perfect, but I find now, on investigation, that every trade is organized into local trades unions, and that they have general conventions or assemblies which lay down the laws for the local unions; that in every one of the northern States these conventions exist, and that they have just now called a national convention to meet at Chicago in August next to organize a national labor party, with the intention, doubtless, that they shall run candidates for public office.

Q. When you say the trades unions are less perfect in America, do you mean that their control of the labor market is less effectual?—A. I think we have not felt it as you have felt it; my idea is that they have not reduced the thing to so perfect a system of watchfulness over the members; but I do think that the organization now pervades the whole of the northern States, and almost every branch of industry. Of course I have been getting information since I was last here on these points, and I find that the thing is much more perfect in America than I supposed at the time I gave my testimony.

By Mr. MATHEWS:

Q. Have you considered whether the ulterior object in demanding that eight hours shall be a day's work is to attempt by and by to get the same wages for eight hours as are now given for ten hours?—A. I have not the slightest doubt that that is the aim of the workingmen. They first tried to get the same wages for eight hours as for ten hours. They failed in that, and now there is no doubt that, in establishing the eight hours, they look forward to having the same wages as they now have for ten hours.

Q. Eight hours is what you call in America the platform of labor?—A. Yes.

Q. And eventually their object is to get the same wages for eight hours as previously they had for the longer time?—A. Yes. I should like to put these resolutions to which I have referred in testimony; and if you will allow me to read them, I think they will give you the best idea I can possibly give, from the workmen's mouths themselves, of the present state of opinion among them in the United States.

By Mr. BOOTH:

Q. They will show us what the workmen are, in fact, aiming at?—A. Yes. This is the report of the committee, which report was adopted, I may say, by the convention: "Your committee, to whom was referred the all-important subject of good and welfare of this body;" this being a convention of the working men.

By the CHAIRMAN:

Q. Simply as workingmen, not as working builders only, for instance?—A. No; a convention of delegates representing the various local trades unions in the State of New York, so that it is practically a parliamentary body: "Whereas the legislature of the State of New York did, at its session, pass an act entitled the eight-hour labor act, making eight hours a day's work in the absence of any contract; and whereas it is only just and proper that the workingmen of our State should enjoy the benefits intended to be conferred by said act; and whereas our employers, as a body, have shown an unexpected hostility to the adoption of the eight-hour system, even though we should concede a corresponding reduction of wages, and notwithstanding the fact that we have an eight-hour law, so called, have not enforced it, but still continue to work their employés as heretofore, and to cause the convicts in our prisons still to be worked ten hours: Therefore, *Resolved*, That wishing to do equal and exact justice to all men, and being extremely anxious to avoid all trouble or cause of disagreement between ourselves and our employers, we will insist upon no extreme measures, nor act in a manner calculated to entail loss upon those who employ labor. *Resolved*, That in order to give our employers ample time to fill all contracts predicated upon the present system of labor, we will not insist upon the adoption of the eight-hour system until the —— ——, and that, commencing with that date, we will work eight hours for a day's work, at a reduction of twenty per cent. of the rate of wages then paid, and that all time worked over eight hours shall be paid for at the rate of time and a half time. *Resolved*, That whether we are successful or not in our present efforts to secure the hours of labor, we will still continue to advocate this reform, and, having full confidence in the justice of our cause, we will never cease to advocate it until we secure its adoption throughout the entire continent." The report was accepted and the question was deferred for further action; then, finally, the report was adopted, and the time filled in the 1st of November next. That is the platform which they adopted. And then there is a resolution "for a committee to wait upon Governor Fenton, and ask him to issue a proclamation declaring that eight hours is a legal day's work on the public works, in conformity to the law of last winter;" and that was adopted.

Q. The "public works" means works on which convicts are engaged, I suppose?—A. The public works with us, I should think, would mean canals and public works which belong to the State. I should doubt whether they mean works in the State prisons, but it is quite evident that they do contemplate reducing the labor of the convicts in the State prisons.

By Mr. MERIVALE:

Q. Can you at all form an estimate of what proportion of the population in such a State as the State of New York, among those properly called working men, would be men who would take part in these unions?—A. The percentage would be quite small of the whole number, but I should not like to make an estimate now.

Q. It would be larger, I presume, in New York than almost in any other State, except in the New England States?—A. I think that in the eastern States, New York, New Jersey, and Pennsylvania, and the New England States, the percentage would be larger than elsewhere; but I think that of the whole number of the population, the number that belong to trades unions would be comparatively small. It would be a guess, as we say, an estimate, but I cannot imagine that it would be more than ten per cent.

By Mr. MATHEWS:

Q. Have you ever considered, supposing that this scheme for limiting labor to eight hours a day is carried out and acted upon, and that other classes find it necessary to limit themselves to eight hours a day, namely, merchants, lawyers, public functionaries, &c., what the effect would be upon society?—A. I suppose that if there were a general reduction of the hours of industrial work or other work, there would be a reduction of production, that the work would have less stock to distribute among its various members, and we should all be poorer in consequence.

Q. Beyond that, would not the effect of having sixteen hours' idleness act very prejudicially upon the morals of the community?—A. I think that it depends very much upon the training which the man who has the leisure has received. I can readily understand that a man like Charles Lamb, when relieved of his work at the India House, found it very profitable to have leisure time. Many people would use the leisure well, while other people might waste it in dissipation. But that is a matter of training. I think that if the working men had a perpetual holiday, without any preliminary training, they would plunge into dissipation and vice; but, on the other hand, if they had been trained to artistic and intellectual pursuits at some portion of their lives, they would make good use of their leisure.

Q. But men like Charles Lamb do not abound?—A. I agree with you, and I cannot lay down so broad a proposition on the subject as to include all. I think, as a general rule, that people become vicious and dissipated when idle, and that they are happy when they are fully employed.

By Mr. HARRISON:

Q. Do you think that, with the progress of civilization, (supposing civilization to progress in a reasonable manner,) working eight hours a day would be less favorable to the general condition of the workmen and of the world than working ten hours a day?—A. I cannot say that it would. I have to apply all these questions to my own feelings and my own case, and I should say that I would consider it a very desirable thing personally to be relieved from close attention to the business out of which I get my livelihood at the end of eight hours, and I could employ my time profitably in other ways. I cannot say that I think a reduction of the hours of labor would be injurious to society; but I can say that I think that a reduction of the hours of labor would be injurious to society, unless it were accompanied with proper training.

By Mr. MATHEWS:

Q. Unless, in fact, the virtue predominated over the vice?—A. I think that everybody must be trained for leisure.

Q. To adopt the leisure, without a previous preparation for it, you think would be injurious to the welfare of any society?—A. Yes.

Q. You spoke of women and children, and you stated that you considered that the labor of women and children should not be brought into operation, because it tended to reduce the rate of wages generally. Have you ever considered whether it is not necessary to employ children in order to have skilled adult workmen hereafter?—A. The process of industrial education, of course, must begin at some time or other in life.

Q. Do you mean by education simply a school education, or education for a man's after occupation in life?—A. By education I mean both intellectual education and industrial education; that is to say, the education of a man in his trade. I think that there is a time when both of those should commence, and I think that the intellectual education should begin before the industrial.

Q. Do you think that the industrial should begin during childhood or boyhood?—A. I think it is very desirable that it should.

Q. So that, if you were to throw out of employment children of a certain age, you would cut at the root of the process by which skilled labor is got, both in this country and America?—A. I think that if I were to assent to your proposition I should be doing injustice to myself and injustice to the question. I clearly think that the young should be trained for industrial pursuits; but I think that for them to be confined and restricted to industrial pursuits, that is to say, to receive no other education but an industrial education, and especially the hard kind of labor I have seen them subjected to here, is decidedly wrong, and it is in that point of view that I make my criticism. I do not object to industrial education, but I object to it to the exclusion of other education. I see children put to work in Europe at a very early age, and being kept at it always, they lack the other training which I think is indispensable to fit them to deal with just such questions as we are now dealing with.

By the EARL OF LICHFIELD:

Q. At what age do you think that that industrial education should begin?—A. In our country, as a matter of practice, we usually begin at fourteen; but at Paris I have seen schools, under the *Frères de la Doctrine Chrétienne*, in which the trade instruction and the intellectual instruction goes on together, and there they take children as young as eight; but both branches are taught in the same schools.

Q. In that case, how is the time divided between the industrial education and the intellectual education?—A. Four hours is given to the intellectual education and eight hours to the industrial training.

By Mr. MATHEWS:

Q. Is it all done under the same roof?—A. Yes.

By Mr. HARRISON:

Q. Are you referring now to children of eight years of age?—A. They begin at eight years of age.

By Mr. MATHEWS:

Q. Would it be practicable to carry on that process with the generality of the trades in England? Take the iron trade, for instance?—A. I should say that it would not be practicable in the iron trade. They have been compelled to select a few of the artistic branches of business, such as the manufacture of opera-glasses, trunk, frames of pictures and looking-glasses, and things of that sort, things mainly connected with the artistic business of a large society. I think that a system of education is quite possible in iron works, because at Creusot, one of the largest iron works in the world, I found that the children were all instructed in the schools and that the education was of a class to fit them to become iron workers; for instance, they were taught arithmetic, reading, and writing and drawing, and the girls sewing. They were careful, and I think wisely so, not to carry the culture beyond the purposes to which these children were required. Music they were taught also.

By the EARL OF LICHFIELD:

Q. At what age do the children commence working at the iron works in your country?—A. In our country the youngest will be found among mines, and I know of no case where they are under 13 or 14 years of age. The work they do there is usually to drive a horse.

Q. And do you think that, beginning at 13 or 14 years of age, they can obtain that amount of training which is necessary to enable them to become efficient?—A. I have no doubt of it.

Q. Of course the iron works are kept open night and day?—A. Yes.

Q. Are the children at that age, 13 or 14, employed during the night, like the others?—A. They are compelled to work at night. They are the catchers around the small trains; for example, it is necessary to have small boys, because they are quick and active to catch the rods, and for that purpose they must be there night and day.

Q. That you find is necessary?—A. That I find is necessary, and, according to my observation, not injurious.

By Mr. HARRISON:

Q. In the addition you have made to the evidence given on the last occasion, you have said something about the general character of unionism as you have observed it. Speaking generally, to what are you disposed to attribute the origin of unions; to what general cause do you suppose that unions are due?—A. I have stated in my testimony previously that I believe that this restlessness and uneasiness which exist among the laboring men all over the world, and especially among those who are more enlightened, arise from two causes; one of those is the general introduction of machinery, by which production has been enormously increased without (as the people believe) a corresponding rearrangement of the laws of distribution of the proceeds; it is a feeling arising out of the belief that the profits of industry are not distributed fairly. That is the first cause. Secondly, the large introduction of gold from California and Australia has disturbed the relation of value, and labor, among other commodities, has had its value disturbed. It is reaching an adjustment which it would reach without the trades unions, but which these working men believe they will reach more readily by the trades unions.

Q. Then you believe that the existence of trades unions is a result of far more general causes which exist among the working classes as a whole?—A. I think that the trades unions are a symptom of the readjustment of the relations of capital and labor. The production and the industry of the world have outgrown the principles to which we have been trained; and the world is now engaged in readjusting these questions. And I am confirmed in that view by these facts: I find that this restlessness seems to prevail just in proportion to the intelligence and the wages of the working men; the more intelligent they are and the higher wages they get, the more restless they seem to be. In France, for instance, on the other hand, where I found the workmen much more ignorant than here, I found much more contentment. The contentment seems to be in proportion to the ignorance, in other words.

Q. Have you found analogous tendencies and similar objects to those which trades unions show are at work in the working classes to exist among those who are not members of trades unions?—A. Yes; I think that there are a great many who are not members of trades unions who are striving to reconstruct the industrial system upon another basis; that is to say, the co-operative basis; and in Germany, especially, they have made considerable progress in that direction.

By Mr. MERIVALE:

Q. You refer to the Schultze-Delitzsch movement?—A. Yes.

By Mr. MATHEWS:

Q. Do you think that the discoveries of gold in Australia and California have so acted as not only to have increased the value of commodities generally, but that the value of labor has not increased in proportion to the value of other commodities?—A. I am not certain that it has not, and if I estimate it now by the results to be gained by the employment of labor in England, the United States and on the continent, I am inclined to think that labor has got its fair share because I know of no staple commodity which we can produce in the United States at a profit, and I am assured by those connected with the iron trades here that it is the case here also, and on the continent I find the same. Hence all this immense development of manufactures is, to-day, without advantage either to the proprietor or (if the workman is to be measured by his contentment) to the workman, though perhaps the world has gained by the cheap rate at which they get the commodities.

Q. The workman, in entertaining the impression that all other descriptions of value having risen, his labor is not sufficiently remunerated, may be right or wrong, but hence arises the organization of trades unions for the purpose of accomplishing what cannot be accomplished by a natural process?—A. I think that that has very much to do with the wonderful extension of trades unions.

Q. And the movements of large bodies of working men are not generally governed, I presume, by that philosophical reflection that the movements of the higher classes are governed by?—A. I would not like to state that proposition, but I would put it in this shape, that the more enlightened and experienced people are, the wiser their movements are likely to be. It may be that the workmen are wiser than their employers. I should like, in answer to that question, to read one resolution which was adopted at Albany as showing the feeling among the working men: "Mr. O'Donohoe read some resolutions setting forth that the interests of capital and labor are antagonistic, and that therefore it is highly advantageous to workmen to become employers. It therefore calls attention to co-operation as the true mode of settling disputes between the two classes, and urges mechanics to form co-operative shops. Mr. O'Donohoe said that he had tried co-operation for some time, and he was well satisfied with it. His shop embraced about 40 men in the moulders' trade, and he thought that all troubles had been finally adjusted. The resolutions were adopted." There is a resolution setting out broadly that "the interests of capital and labor are antagonistic." Now, in answer to the question whether intelligence is likely to come to more sound conclusions an ignorance, I answer yes; and I give this as evidence of it. Here a resolution of the working men, setting out that "the interests of ıpital and labor are antagonistic."

Q. A resolution cutting at the root of all society, in fact?—A. Yes.

By Mr. MERIVALE:

Q. Your opinion is that the fall in the value of gold has affected the rice of wages generally?—A. I think it has.

Q. Is anybody ever paid in gold in America?—A. At present not, but ormerly they were paid regularly in gold. Since the war, that is to say since 1862, no one has been paid in gold.

Q. Do you suppose that the fall in the value of gold affects a currency of paper?—A. For example, a dollar in gold to-day will purchase one dollar and forty cents in currency in the United States. If gold should fall in value to-morrow, less than a dollar and forty cents in currency would buy a dollar of gold.

Q. No doubt that is so; but do you think you can generally answer that a currency in paper is depreciated by reason of a depreciation of gold?—A. I think that if gold depreciates, paper will appreciate with the fall in gold.

Q. You say that in your opinion a movement for eight hours as a day's labor means ultimately eight hours' labor at the same wages which ten hours' labor now gets?—A. I have no doubt that is the aim of the men, and that they think they can succeed.

Q. Do you think it probable, supposing they should succeed in reducing the hours of labor to eight, that men would become able to do in eight hours what they now take ten hours to do?—A. I think not. There are some branches of business in which they could, but if you take the iron business for example it cannot be done, because there is a question of revolutions of trains, and of course the yield is proportioned to the number of hours that the trains are kept in motion.

Q. But in cases where the gain depended on the energy of the men alone, do you think that if you reduced the hours of labor to eight they would be able to do as much in eight as they now do in ten hours?—A. I think there are cases in which eight hours' labor would be as good as ten, but if you or I had a piece of hard intellectual work to do, which was going to take us a month to accomplish, I think that we should be likely to accomplish it as well with eight hours' work a day as with ten. I think that that is the experience of all men who have that kind of work to do.

By Mr. MATHEWS:

Q. In all manual labor, or where strength and skill are required, would it be possible to do as much in eight hours as in ten?—A. I think not.

Q. As a law, therefore, a reduction by one-fifth of the hours of labor would involve a reduction by one-fifth of the production?—A. As a law, I think that it might be stated in that way.

By Mr. BOOTH:

Q. The energy that is brought to bear upon piece-work would be an important element, would it not?—A. Yes; in piece-work, in many cases, the men would do as much in eight hours as they ordinarily do in ten without piece-work. But, again, that would not apply to many branches of the iron business, because there is a positive question of time and nothing else, as, for instance, where a man has to watch a machine going.

Q. As a general rule, more would be done in ten hours than in eight hours?—A. As a general rule more would be done in ten hours than in eight hours, but I think that the general result of piece-work is to increase the quantity done in a given time.

By Mr. HARRISON:

Q. Going back to a former subject from which we have wandered, you say that you seem to see in England something like a species of rebellion, of which unions and unionism appear to be one example?—A. Certainly.

Q. You say, "This appears to be the point at which you have arrived in England, and against which there is an instinctive rebellion, both among the enlightened and ignorant, manifesting itself among the latter in organizations at war with the fundamental principles of social order," under which "organizations" you include unions?—A. Yes.

Q. You have explained, therefore, the form which this rebellion takes among the "ignorant;" I want to ask you if you will do the same thing on the other side, and specify what indicates the rebellion amongst the "enlightened;" what did you mean by that?—A. I mean by that that all men of enlightened views are very busily engaged in considering the relations of capital and labor, and are trying to find out a remedy for what they consider to be the wrongs of labor, if you like to put it so. That is to say, an intelligent man goes into an iron works and sees a class of labor employed there which does not strike him as proper, for instance women and children, and he says, "We must change all this. Is there not some mode by which we can improve the condition of things and improve the condition of the laborer? Here we have prices so low that neither capital nor labor can benefit by it; is there any arrangement by which we can bring things back to a better system?" It is for such reasons that they rebel against the system.

Q. You mean intelligent social reformers?—A. Certainly, that class of people, and I include statesmen.

Q. When you speak of "the fundamental principles of social order," do you mean the present social order amongst us, or do you mean the right, normal, and healthy social order?—A. Of course I mean what I hold to be the right and healthy social order. The fundamental principles of social order I understand to be the security of capital, the security of person, and the right of free discussion. Those seem to me to be the fundamental principles of social order—that is the way in which we usually define it—and I say that those principles are violated by some of these organizations. In the first place, capital is destroyed; personal freedom is also destroyed, because the trades unions will not permit the men to do what they would do of their own free option. Personal freedom is attacked, and capital is attacked, and that, I say, is being at war with the fundamental principles of social order.

Q. When you speak of a rebellion on the part of the enlightened, you think that that is an attempt to introduce changes which would not be antagonistic to those principles of social order?—A. On the contrary, I think that the enlightened people want to make the changes conform to the principles of social order, and I think that the other people are attempting to do the same thing, but by mistaken means, not using wrong means by intention or design. I wish to correct another misstatement in my testimony. I stated that the moulders' association at Troy was not regarded as a pecuniary success. Since I made that statement I have received the report of the Moulders' Union, in which they claim that it is a success, and say that they have been able to increase their capital and pay as large wages as are paid in private establishments, and that they succeeded in establishing the works without the aid of outside capital. I stated formerly, from information which I had, that the capital was furnished by benevolent gentlemen, but in the report which I have in my hand they state that they have had no help of that kind.

By Mr. MATHEWS:

Q. Does the report say that they pay any dividend upon that capital?—A. Yes; it says that they do pay a dividend, and that they pay the same rate of wages as private establishments, and that the concern is regarded as a success.

Q. What dividend do they pay?—A. They commenced with a capital of $20,000, and it is now increased to $50,000, after three years' operation.

Q. They have accumulated, therefore?—A. Yes, they have accumulated.

By the CHAIRMAN:

Q. In regard to the eight hours' labor law, there are two hours thrown upon the hands of the working man if he was previously working ten hours?—A. Yes.

Q. Have you a distinct idea of what you call amusements? because he is to employ those two hours in amusements, I understand?—A. The theory is that he is to employ that time in recreation and improvement.

Q. If you have ever been acquainted, as I am sure you have, with men in the time when their faculties, bodily and mental, are in their highest energy, can you conceive a greater burden to such men than to order them to desist from pursuing an important purpose?—A. I think that it would be an act of tyranny.

Q. And is there any way of pursuing an important purpose in any rank of life except by work?—A. I think that a man who feels that he has a great object to attain never measures his effort by time at all; it is a mere question of physical ability with him how long he can work in order to accomplish the end at which he aims, and I think that this attempt to bring down the hours of labor to eight by an arbitrary enactment is at war with the fundamental principles not only of social order but of human nature.

Q. Slack men may like to stand in the sun, but the energetic men would feel themselves afflicted by a sore grievance if they were not permitted to pursue an important purpose at their own option?—A. Yes.

By Mr. MERIVALE:

Q. Do you think that in all public offices they ought to work ten hours instead of eight?—A. I am unable to speak of what should be done in public offices.

By Mr. HARRISON:

Q. Do you think that a twelve or a fourteen hours' system would be a movement for the better?—A. No, I do not; I do not know whether eight hours, or ten hours, or twelve hours is the better average condition for the laborer, but my objection is to the system which compels people who are willing to work more than eight hours, and who feel that they could work more than eight hours, to restrict themselves to eight hours; and that is the tyranny which the trades unions would inflict upon labor generally.

By Mr. BOOTH:

Q. Your objection is to any compulsory system?—A. My objection is to any compulsory system. I wish to leave it free between the workman and the employer.

By Mr. HARRISON:

Q. Your opinion has not been given at all on the relative advantages of an eight-hour system or a ten-hour system, provided it is left perfectly free?—A. No; I have given no opinion upon the question which is the best for the normal state of society.

By Mr. MATHEWS:

Q. Is not the rational state of society this—that every man should be left free to work as many or as few hours as his physical strength enables him?—A. Yes.

Q. And any restriction upon that by co-operative societies, or any restriction which compels him to deviate from his natural practice, is an injury to society?—A. Yes; I think that the restriction should only come in among people who are not able to take care of themselves—women and children, and idiots. I mention women as the more helpless members of society as contrasted with men; I think women and children, and those persons whose intellects have been disturbed, are comparatively helpless, and that the law, therefore, must make provision for them.

Q. In regard to the eight-hour system, what would be hard labor for one person with a feeble constitution and feeble powers would be idleness for another man?—A. Yes.

Q. And I think there is an old hymn, familiar in this country, which says "Satan finds some mischief still for idle hands to do?"—A. Yes; we have the same in our country.

By Mr. HARRISON:

Q. What form does the legal compulsion take in the eight-hour law? —A. The legal compulsion would be that on public works, all employment by the state, eight hours would be a day's work, and nobody could work for ten hours; at the end of eight hours the bell rings and the men quit work.

Q. It would be illegal to work longer?—A. Yes; no public officer would be allowed to make the men work for over eight hours, unless at a rate of wages specially agreed upon.

Q. You say that each man should be left free to work as many hours as he thought convenient. In great works, such as iron-works, factories, and so on, it is impossible for men to work different hours, is it not?—A. Yes.

Q. How do you propose to meet that case?—A. The thing has regulated itself in this way: experience has shown about how many hours per day men can work and maintain themselves in good bodily condition, and by long experience the thing has adjusted itself to that condition, and only the men who can work the number of hours which is found to agree perfectly with the bodily condition of the men come there and work; the others quit it.

By Mr. MATHEWS:

Q. In fact, you want men of a higher physical condition to work in iron works?—A. Yes; and the number of hours, from the nature of the case, is adapted to the abilities of the men to labor.

By Mr. HARRISON:

Q. You say that the proper amount of work is the maximum which can be worked by strong, able men without injury to their physical condition?—A. Certainly.

Q. Do you intend to exclude from the consideration their intellectual condition or their education?—A. Yes, I have excluded that in giving you the estimate which I have given, because in the iron works that really does not enter into the question.

Q. Supposing the case of a thousand men who have been in the habit of working 10 hours without injury to their physical condition, but just up to that limit, and who then say, "It is true that it does not injure our physical condition to work 10 hours, but we think that if we work eight hours we shall improve our intellectual condition;" does that seem to you a reasonable basis for them to agree upon in order to fix the hours which the people work?—A. I should think it is perfectly competent for the working men to take that question into consideration in making their arrangements with their employers. On the other hand, the employers may say, "But after working 10 hours you have still sufficient time for the improvement of your intellect and for recreation;" and that is a question of fact.

Q. If the workmen say they have not sufficient time, what then?—A. If the workmen say they have not then the thing must be adjusted between the two classes? It is like a thousand other questions in society, and they must come to an understanding about it.

Q. There are other elements to be taken into consideration in fixing what should be the hours of work in a large factory, or work, besides the single one you have just mentioned?—A. There are a great many questions to be taken into consideration. The conditions of business, for example, compel us sometimes to cut down the hours of business; sometimes we can only work half-time.

Q. I am speaking of the normal condition, when things are in full work?—A. I think that society always has, in any particular region, the best arrangement of capital and labor that is possible with the knowledge and the means at command of the people who are there. I think that in each place they always arrive at the adjustment which is the best practical adjustment consistent with the amount of knowledge and the amount of resources at command. I find that in one place the adjustment is much more favorable to working men than in another place, and in the same place it is more favorable at one time than at another time. In the United States at present it is an adjustment more favorable to the workmen than it is in England; in England it is more favorable than in France; in France it is more favorable than in Belgium. That is a question of national conscience and of the knowledge and the means at command.

Q. In point of fact the hours of labor are, in the nature of things, variable, and will alter with the progressive civilizations of the community?—A. Beyond doubt, and it would not astonish me to see eight hours as generally recognized as a day's labor as ten hours is now.

By Mr. MATHEWS:

Q. Is it not a fact that when men are getting full wages they dictate their own terms to their masters as to the length of time they will work? For instance, to take the case of iron works, if the master requires the men to work full time they say, "We will not work full time; we find that we can do as well for ourselves in working five days a week as six?" —A. That is my own experience, and that is the experience I think of all iron-masters; but with greater encouragement given to the workmen, and with a different arrangement for payment, I think that might be changed. I think that men are just as anxious to earn good wages and to acquire property when they are sufficiently educated as the owners are.

Q. Do not you think that that is better left to the ordinary operation of the relations between employers and employed than to any fixed arrangement that can be adopted?—A. I think that, as a general principle, it is better to leave these questions to the people who have to deal with them practically, but I am not prepared to say that there may not be grievances so great and persisted in so long, (from habit, perhaps,) that it may be that the legislature should step in and interfere. I think that great wrongs are permitted to go on for some time if left to the voluntary action of the people who have personally to deal with them, and in such cases the legislature should interfere. But I think that if the legislature interferes it should be done with great deliberation and after careful examination.

Q. Only with reference to the interests both of the employer and of the employed?—A. I think that the interests of the community are superior to the interest of any particular employer or employé, and if the legislature find that there is a grievance which employers and employés will not correct, it is the bounden duty of the legislature to correct it.

By Mr. HUGHES:

Q. When you speak of different arrangements between employers and employed, do you think that if the employed were paid by a share in the profits this state of things would pass away?—A. I think that it could be very much ameliorated. In very many branches of business it might be entirely remedied, but there are some branches of business in which I have not seen my way clearly to such an adjustment.

Q. As far as you know, is such a plan applicable to iron works?—A. I think it is.

Q. And coal works?—A. I think it is perfectly applicable to coal works?

Q. I think there has been even in Pennsylvania some attempt of that nature?—A. I have never known any attempt of the kind in Pennsylvania. I have never known any attempt of the kind either in an iron works in America or in a coal works.

By Mr. MATHEWS:

Q. Have you ever known a case of successful co-operation?—A. If I am to believe the statements which are published in regard to the operations of Schultze-Delitzsch, I must say that there are many such in Germany.

By Mr. HUGHES:

Q. Did you ever hear of Briggs & Co., in England?—A. Briggs & Co. I know nothing about. I wish to say that since I testified on the last occasion I have received advices from home of the organization of a very large number of these co-operative associations. It seems to be the case that one of those epidemics which occasionally break out in society has broken out on our side. They are of both kinds, both an association of the capitalist owner with the workmen and an association of workmen by themselves, and both will be tested I think on a very extensive scale in a way that will conform more nearly to English notions than continental experiments can. Continental notions are so different from yours that no experiment there I think could be taken as conclusive with regard to English industry, but the experiments in the United States I think will be more satisfactory to your view. I anticipate failure in many instances and success in others. Where there is talent, honesty, and care, there will be success; where there is dishonesty, and idleness, and neglect, there will be a failure.

By Mr. BOOTH:

Q. Is the present state of the law in different States such as to permit of the experiment being fairly tried, or would it be necessary that the law should be amended?—A. It will be necessary to amend the law in order to try it upon the system which I think most favorable, but the law is sufficiently broad to permit the arrangements to be carried out which they are now trying, and which I think are not the best, though I think they have got the elements of success.

By Mr. HUGHES:

Q. But I think you will find that in some places the law gives perfect facilities at present, for instance, at Chicago. Within the last six weeks I have had three applications from masters in America, who are thinking of adopting the method, for copies of the rules in use here, and for statements as to what has been done here; and in one instance, certainly the application from Chicago, the letter said that there would be no difficulty whatever as far as the law went. Of course that might be a statement made off-hand?—A. The law in Illinois will permit the organization of joint stock co-operation, and the owners may make such contracts between themselves as they may see fit, and the Northwestern Manufacturing Company of Chicago, as a matter of fact, has been organized upon that basis. It is not organized, however, upon the basis which I consider most favorable to success.

Q. You surely consider that the most favorable system would be that in which the employers and employed both hold capital stock?—A. Yes, I do, and yet I do not think that this one at Chicago is organized upon the basis most favorable to success, and for this reason: the stipulation is that the capital, which is estimated at $300,000, and which is a good deal more than the actual capital that they have, is, under all circumstances, pledged to receive ten per cent.

Q. Ten per cent. may be too high a figure, but you would surely say that some fixed interest must be paid upon capital *pari passu* with wages? —A. Supposing that there is not enough to pay both the men their wages and the capitalist his interest upon the capital, who is to get the money? Society has decided long ago that the workmen shall have it, and I suspect, as the stomach is the foundation of all business, that that decision is a wise one, and therefore any decision which asserts that there shall be a prior right for capital to take ten per cent. will fail. It will fail inevitably, because there must be cases in which the profits will not yield that return to capital as well as paying the wages of the men.

By Mr. MATHEWS:

Q. It will fail, in fact, because there is no provision for recouping the master when such circumstances arise?—A. Yes.

By Mr. HUGHES:

Q. On the average of years, surely businesses of that kind do not lose; they make profits on the average of years, or else nobody would carry them on?—I can only say that I know of many businesses in the United States which have not made money on the average of years, but on the contrary have lost money. The iron business has certainly been the source of immense losses. I have testified here before of the number of iron works that have been sold out, and I doubt whether we could point to ten families in the United States which have been successful in the iron business. I only refer to that as showing the necessity for an arrangement which conforms to experience in regard to business. The workmen have to be fed. The workmen do not know the fact that the business is carried on in order to satisfy that prior lien of theirs upon the property, and they are making war in the United States and here and in France upon the business on which they have a prior lien. The lien may not be large enough in certain cases, but the broad fact that the workman has the prior lien upon every business in every branch of labor is an unmistakable one.

By Mr. MATHEWS:

Q. The difficulty will be to satisfy that prior lien. If the result of the co-operative society did not satisfy that lien sufficiently, and if it did not satisfy the percentage on capital besides, it must fail of itself?—A. Yes.

Q. If the workmen only receive bare subsistence wages until the result of the undertaking is known and the profits are realized, do you think there would be a difficulty in their making a fund out of subsistence wages, and out of any profits that they might be entitled to, which would enable them to provide against such a contingency as an unsuccessful year?—A. Yes, I should have supposed so but for the fact of the extent to which the principle of Schultze-Delitzsch has been adopted in Germany. That is really a most marvellous thing. Those people actually abated 20 and in some cases 40 per cent. to get such a fund, and I am satisfied that with the temper of our people in the United States I could go to my leading workmen and say, "We shall go on paying you your present rate of wages, but I ask you to leave behind so much as will form a fund for that purpose," and they would willingly consent to do so.

By Mr. HUGHES:

Q. Did you ever hear of such things as bare subsistence wages in the United States?—A. I have heard of it, because we have had such things as labor going down to a very low point.

Q. I remember, in 1848 and 1849, when many of the associations in Paris were going on for months, the men drawing only 10 francs a week on account of their wages. You never heard of such wages as those in

America?—A. I can remember when wages have been down in America, in times of depression, to as low as 50 cents per day, which would be about 2*s*. per day in English money; that is as low as I have ever known anything got in America, and that was very exceptional indeed. There is one other thing which I wish to correct. I saw some comments in the London Times which seemed to look to testimony on my part that certain puddlers had murdered other puddlers coming to Pittsburg. Now I was very careful to state that I spoke of the murders only as evidence of the demoralization of a community where a strike had been going on for months, that I was merely informed that these murders had taken place, and that I did not know by whom, so that any inference from my testimony that one set of workmen had murdered another set was quite unfounded.

By Mr. HARRISON:

Q. That was clearly so put in your evidence, was it not?—A. I think it was.

By the EARL OF LICHFIELD:

Q. You said with regard to the employment of children in iron works in America that they were not employed before the age of 13 and 14.—Does that apply to other trades in America?—A. As a general rule it is a rare thing to see a young child not 13 or 14 in any physical employment, very rare indeed.

Q. Are those children up to the age of 13 or 14 generally at school? A. Yes.

Q. And have you any provision, generally speaking, in the iron works and in other trades for the education of those children, continuing after the age when you say they begin to be employed in the iron works?—A. No, there is no provision, except that in the large cities there are night-schools, and in New York, as I testified, the Cooper Institute affords the very largest possible instruction to mechanics. That is a private endowment.

By Mr. MATHEWS:

Q. I think you gave us some particulars of the Cooper Institute?—A. I did mention some particulars in reference to that. I wish to correct my testimony on another point. A Welsh ironmaster tells me that I am mistaken in my testimony as to women lifting those heavy bars of iron of which I spoke, two inches thick, five feet long, eight inches wide. I say that I actually saw one of those lifted, but this gentleman informs me that these heavy bars are lifted by men who are sent to do this heavy work. I merely saw the women making the piles, and I inferred that they put the tops and bottoms on because they were the only persons there, but I am informed that it is not so.

Q. So that the employment of women in iron works is not so heavy as you thought it was?—A. I still repeat my testimony that it is a great deal heavier work than I have ever seen women do before; but I correct that particular statement as to the bars.

By Sir D. GOOCH:

Q. Is there any compulsion in America in regard to education?—A. No compulsion in any place, except perhaps recently in Massachusetts. I have heard recently that a law for compulsory education has been passed there, but I am not sure of it; but in the other States there is no compulsion.

By Mr. BOOTH:

Q. Have you read the statement of the "Times" correspondent to that effect, that there is compulsory education?—A. I have not read the statement, but I know that there is no compulsory education in New York or New Jersey. It is just possible that there is in Massachusetts.

By the EARL of Lichfield:

Q. But education is provided out of the rates?—A. Education is paid for by the public and assessed for by rates on the district, and most of the States have school funds out of which they make a distribution annually to each district.

Q. And the children up to the age of 13 or 14 avail themselves very generally of that opportunity of education?—A. Very generally.

Q. I think you say that a great number of young persons after the age of 13 and 14 avail themselves of night-schools?—A. In the cities.

Q. And do not you attribute that very much to the fact of their having been able to obtain tolerable education before beginning their employment?—A. No; I am sorry to state that the opposite is the case; that the ones that go to the night-schools are usually those that have had no opportunity of education in the day-schools. Those who go to the night-schools are, in New York, mostly foreigners who want to learn the language, or mechanics who have not received the ordinary elements of education. But in the case of the Cooper Institute, those who attend the classes are persons who have received some education before.

Q. Is that an industrial education? Are men instructed in their trades?—A. No; they are instructed in that kind of knowledge which is necessary for them to conduct their trades intelligently; for instance, the machinist is taught drawing, and we teach chemistry and natural philosophy there. The learning there is all book learning, but it is with reference to the business which the pupil is engaged in.

Q. Is not that statement of yours somewhat remarkable, that those who have had the advantage of an education up to 13 or 14 are not desirous of continuing their education afterwards?—A. No, it is not remarkable, for the reason that these night-schools do not teach anything more than what they have already learned in the day-schools. But in New York last winter a higher grade of school was opened, the first one which had ever been opened there, and it was filled to repletion by those who had been to the day-schools and had learned a certain amount and wished to continue their education.

Q. You have no night-schools where they have an opportunity of continuing their education from the point at which they have arrived at the age of 13 or 14?—A. Except the Cooper Institute we had none until the one that I have just referred to was opened.

Q. Do you not think that if they had the opportunity of continuing their education from the point arrived at, at the age of 13 or 14, they would avail themselves of it?—A. Experience makes me certain of that, because everything of that sort that exists has been used to the fullest possible degree.

Q. Do you find a very marked difference in the intelligence of those who come from this country and Germany and Ireland and other places, when they come to be employed in your works, as compared with those who were educated in your own country?—A. I think that that question would have to be answered with reference to specific occupations. I think that the experience will be different in different operations. In iron works, certainly, we find that the Englishmen are the best workmen, better than those whom we train up; that is to say, as a general proposition, I think the English workmen are better than those we train up in the iron works. And yet there are some branches of our business in which our own people are better; it is a question very much of adaptability to particular kinds of employment. I think that in guide-rolling our Americans are more active and better rollers than the English, but when it comes to puddling the heavy bars the English are better workmen.

By Mr. MATHEWS:

Q. Where you want physical force combined with skill?—A. Where we want physical force combined with skill we get Englishmen.

Q. We can infer from that that they are stronger men that we rear up here than you do in America?—I think they are.

By Mr. HUGHES:

Q. I think your strongest men go west?—A. I think everybody must remark the superior physical development of the Englishmen over the Americans; that you here are a better physically-developed race than we are.

Q. Has that held within the last few years, do you think?—A. It has always appeared to me so. I was struck with it 20 years ago, and I am struck with it now. I consider the English race, as I see it, the best physical race in the world.

By Mr. HARRISON:

Q. In spite of unionism?—A. In spite of unionism; in fact, I do not think that unionism would be possible anywhere else than in England and America, and so far it is a healthy sign.

The witness withdrew.

APPENDIX 1.

POOR RATES AND PAUPERISM.

Return (in part) to an order of the honorable the House of Commons, dated 9th July, 1867, for return of "Comparative statement of the number of paupers of all classes (except lunatic paupers in asylums and vagrants) in receipt of relief on the last day of each week in the months of April, May, June, July, August, September, October, November, and December, 1866 and 1867, respectively; also for the months of January, February, and March, 1867 and 1868, respectively;" "statement of the number of paupers, distinguishing the number of adult able-bodied paupers relieved on the 1st day of July, 1867;" "similar statement for the 1st day of January, 1868;" "statement of the amount expended for in-maintenance and out-relief only, for the half year ended at Michaelmas, 1867;" "similar statement for the half year ended at Lady day, 1868;" "statement of the amount of poor-rates levied and expended during the year ended at Lady day, 1867;" "and of the number of insane paupers chargeable to the poor-rates on the 1st day of January, 1868."

FREDERICK PURDY,
Principal of the Statistical Department.

POOR-LAW BOARD,
Whitehall, July 9, 1867.

QUARTERLY STATEMENT AS TO PAUPERISM, MICHAELMAS, 1867.

(Paupers in lunatic asylums and vagrants not included.)

The present return completes the monthly series for the quarter ended at Michaelmas, 1867. The four following tables are given in continuation of those prefixed to the monthly publication for June last.

The tables are—

1. England and Wales; the pauperism in the consecutive weeks of the quarter.
2. (England and Wales;) the comparative pauperism of the quarter.
3. North Midland, Northwestern, and York divisions; the comparative pauperism of the quarter.
4. The Metropolis; the comparative pauperism of the quarter.

I. In the first table each week is compared with the one immediately preceding it; 884,829 were the numbers relieved in the last week of June, (midsummer;) but in the fourth week of September (Michaelmas) the numbers were 872,620, which is a decrease of 12,209, or 1.4 per cent. less at Michaelmas than midsummer.

TABLE I.—*England and Wales—Consecutive statement.*

Periods.	Number of paupers on the last day of each week.	Difference between the proximate weeks.	
		Increase.	Decrease.
1867.			
June:			
Fourth week	884, 829	....	....
July:			
First week	878, 879	....	5, 950
Second week	876, 670	....	2, 209
Third week	877, 531	861	....
Fourth week	876, 998	....	533
Fifth week	877, 020	22	....
August:			
First week	875, 767	....	1, 253
Second week	874, 211	....	1, 556
Third week	870, 978	....	3, 233
Fourth week	871, 572	594	....
September:			
First week	868, 415	....	3, 157
Second week	869, 067	652	....
Third week	869, 992	925	....
Fourth week	872, 620	2, 628	....

II. The next table exhibits the comparative pauperism during the Michaelmas quarter of 1865, 1866, and 1867.

The paupers in receipt of relief on the last day of the last week of September were—

In 1865	835, 005
In 1866	842, 860
In 1867	872, 620

The paupers in 1867, as compared with those in 1866, have increased 29,760, or 3.5 per cent.; but compared with 1865 the increase was 37,615, or 4.5 per cent.

TABLE II.—*England and Wales—Comparative statement.*

Periods.	Paupers in receipt of relief on the last day of each week.			Difference per cent in the numbers in column (c) compared with each of the two preceding years.			
	1865.	1866.	1867.	Last year but one. (a)		Last year. (b)	
	(a)	(b)	(c)	*Increase.*	*Decrease.*	*Increase.*	*Decrease.*
June:							
Fourth week	853, 073	841, 489	884, 829	....	....	....	....
July:							
First week	846, 082	835, 507	878, 879	3. 9	....	5. 2	....
Second week	842, 469	833, 977	876, 670	4. 1	....	5. 1	....
Third week	841, 567	833, 738	877, 531	4. 3	....	5. 3	....
Fourth week	840, 131	833, 874	876, 998	4. 4	....	5. 2	....
Fifth week	837, 991	836, 486	877, 020	4. 7	....	4. 8	....
August:							
First week	836, 580	839, 493	875, 767	4. 7	....	4. 3	....
Second week	834, 758	840, 146	874, 211	4. 7	....	4. 1	....
Third week	833, 758	839, 278	870, 978	4. 5	....	3. 8	....
Fourth week	833, 042	840, 388	871, 572	4. 6	....	3. 7	....
September:							
First week	832, 293	840, 894	868, 415	4. 3	....	3. 3	....
Second week	832, 443	840, 931	869, 067	4. 4	....	3. 3	....
Third week	832, 705	843, 452	869, 992	4. 5	....	3. 1	....
Fourth week	835, 005	842, 860	872, 620	4. 5	....	3. 5	....

III. The third table comprises the three divisions of England and Wales, in which the principal manufactures are carried on. Taking the returns of paupers relieved on the last day of the last week of September the numbers were—

In 1865 .... 206, 076
In 1866 .... 196, 747
In 1867 .... 202, 853

The increase in 1867, compared with 1866, was 6,106, or 3.1 per cent., but in comparison with 1865 there was a decrease of 3,223, or 1.6 per cent.

TABLE III.—*North Midland, Northwestern, and York divisions—Comparative statement.*

Periods.	Paupers in receipt of relief on the last day of each week.			Difference per cent. in the numbers in column (c) compared with each of the two preceding years.			
	1865.	1866.	1867.	Last year but one. (a)		Last year. (b)	
	(a)	(b)	(c)	*Increase.*	*Decrease.*	*Increase.*	*Decrease.*
June:							
Fourth week	217, 276	198, 360	206, 084	....	....	....	....
July:							
First week	213, 819	197, 207	204, 569	....	4. 3	3. 8	....
Second week	211, 013	196, 246	203, 648	....	3. 5	3. 8	....
Third week	209, 598	195, 887	203, 855	....	2. 7	4. 1	....
Fourth week	208, 517	195, 841	203, 424	....	2. 4	3. 9	....
Fifth week	207, 513	195, 753	203, 427	....	2. 0	3. 9	....
August:							
First week	207, 346	195, 872	203, 011	....	2. 1	3. 6	....
Second week	206, 864	195, 733	202, 701	....	2. 0	3. 6	....
Third week	206, 618	195, 508	202, 195	....	2. 1	3. 4	....
Fourth week	206, 369	196, 407	202, 081	....	2. 1	2. 9	....
September:							
First week	205, 954	195, 989	201, 956	....	1. 9	3. 0	....
Second week	206, 299	196, 053	201, 555	....	2. 3	2. 8	....
Third week	205, 994	196, 424	202, 498	....	1. 7	3. 1	....
Fourth week	206, 076	196, 747	202, 583	....	1. 6	3. 1	....

IV. According to the last returns for the month of September in the three years last past, the number in the metropolis was—

In 1865 .... 91, 022
In 1866 .... 105, 827
In 1867 .... 117, 849

In 1867 the increase in the paupers as compared with those in 1866 was 12,022, or 11.4 per cent.; and on a comparison with 1865, there was an increase of 26,827, or 29.5 per cent.

TABLE IV.—*The metropolis—Comparative statement.*

Periods.	Paupers in receipt of relief on the last day of each week.			Difference per cent. in the numbers in column (*c*) compared with each of the two preceding years.			
	1865.	1866.	1867.	Last year but one. (*a*)		Last year. (*b*)	
	(*a*)	(*b*)	(*c*)	*Increase.*	*Decrease.*	*Increase.*	*Decrease.*
June:							
Fourth week	90,722	96,308	118,982	....	....	....	....
July:							
First week	90,004	98,455	117,738	30.8	....	19.6	....
Second week	89,937	98,778	117,880	31.0	....	19.3	....
Third week	90,109	99,400	118,206	31.2	....	18.9	....
Fourth week	90,218	100,488	118,299	31.1	....	17.7	....
Fifth week	90,232	102,960	118,046	30.8	....	14.7	....
August:							
First week	90,686	105,197	118,347	30.5	....	12.5	....
Second week	91,190	106,100	117,547	28.9	....	10.8	....
Third week	91,317	106,499	117,653	28.8	....	10.5	....
Fourth week	90,963	106,623	117,523	29.2	....	10.2	....
September:							
First week	91,058	106,664	116,983	28.5	....	9.7	....
Second week	90,588	105,624	116,457	28.6	....	10.3	....
Third week	90,696	106,012	116,417	28.4	....	9.8	....
Fourth week	91,022	105,827	117,849	29.5	....	11.4	....

FREDERICK PURDY,
Principal of the Statistical Department.

POOR-LAW BOARD, WHITEHALL, *November* 14, 1867.

MEMORANDUM.

As to the arrangement of the weekly returns of pauperism.

The returns of the number of paupers relieved on the last day of each week do not include the "lunatic paupers in asylums and licensed houses," nor the number of vagrants relieved. These classes form only a small portion of the entire pauperism of the country. According to the latest returns, (January 1, 1866,) the number contained in the two classes was 3 per cent. of the total pauperism.

The pauper lunatics in asylums are not generally subject to variations in number to the same degree as the other classes of paupers; and the number of vagrants relieved by the unions throughout the country has become too small to need a return so frequently as once a week. These considerations led to the exclusion of the two classes.

There are at present 14,886[1] parishes, inclusive of the Scilly islands, in England and Wales, maintaining, or liable to maintain, their own poor; returns of pauperism are received weekly in respect of 14,695 of that number; 191 parishes, incorporated under Gilbert's act, or still under

[1] Many places, not heretofore liable to maintain their own poor, are becoming parishes under the operation of the extra parochial places act; to what extent this will ultimately increase the number of parishes in England and Wales cannot at present be stated.

the provisions of the 43d Elizabeth, made no return of the number of paupers which they relieve.

The returns are arranged under eleven divisions. The union counties which fall under each are shown in the following view:

I. The Metropolis.
1. Middlesex, (part of.)
2. Surrey, (part of.)
3. Kent, (part of.)

II. Southeastern.
1. Middlesex, (part of.)
2. Surrey, (part of.)
3. Kent, (part of.)
4. Sussex.
5. Southampton.
6. Berks.

III. South Midland.
7. Hertford.
8. Buckingham.
9. Oxford.
10. Northampton.
11. Huntingdon.
12. Bedford.
13. Cambridge.

IV. Eastern.
14. Essex.
15. Suffolk.
16. Norfolk.

V. Southwestern.
17. Wilts.
18. Dorset.
19. Devon.
20. Cornwall.
21. Somerset.

VI. West Midland.
22. Gloucester.
23. Hereford.
24. Salop.
25. Stafford.
26. Worcester.
27. Warwick.

VII. North Midland.
28. Leicester.
29. Rutland.
30. Lincoln.
31. Nottingham.
32. Derby.

VIII. Northwestern.
33. Chester.
34. Lancaster.

IX. York.
35. West Riding.
36. East Riding.
37. North Riding.

X. Northern.
38. Durham.
39. Northumberland.
40. Cumberland.
41. Westmoreland.

XI. Welsh.
42. Monmouth.
43. South Wales.
44. North Wales.

The following is a tabular statement of the number of unions and parishes, and the area and population ascribable to each division; but so far only as represented by the weekly returns:

Divisions.	Number of unions, &c.	Number of parishes.	Area in statute acres.	Population in 1866,
1. The Metropolis	39	190	77, 944	2, 802, 367
2. Southeastern	97	1, 426	3, 922, 839	1, 805, 534
3. South Midland	64	1, 447	3, 198, 570	1, 295, 152
4. Eastern	56	1, 644	3, 209, 894	1, 142, 230
5. Southwestern	80	1, 792	4, 989, 180	1, 833, 074
6, West Midland	82	1, 667	3, 851, 187	2, 434, 614
7. North Midland	45	1, 750	3, 533, 919	1, 287, 972
8. Northwestern	40	923	1, 914, 616	2. 923, 487
9. York	60	1, 464	3, 411, 825	1, 899, 233
10. Northern	39	1, 173	3, 492, 322	1, 151, 332
11. Welsh	53	1, 219	5, 210, 747	1, 311, 109
England and Wales, (so far as returned)	655	14, 695	36, 810, 543	19, 886, 104

The absolute as well as the proportional numbers of the adult population, under six industrial classes, are shown in the subjoined table for each division:

Divisions.	Persons aged 20 years and upwards. Classes. 1. Professional.	2. Domestic.	3. Commercial.	4. Agricultural.	5. Industrial.	6. Indefinite and non-productive.	Total.
1. The Metropolis.....	95,925	665,168	135,846	25,260	584,787	110,944	1,617,930
2. Southeastern	90,086	413,256	37,907	187,250	227,043	65,687	1,021.229
3. South Midland.....	22,571	243,351	16,571	169,850	202,169	40,852	695,364
4. Eastern............	21,245	239,981	19,883	164,577	144,230	29,082	618,998
5. Southwestern......	46,662	364,951	29,626	215,503	285,528	57,484	999,714
6. West Midland......	35,203	487,112	44,030	186,661	487,365	76,832	1,317,203
7. North Midland.....	16,930	244,257	16,311	150,417	241,153	29,984	699,052
8. Northwestern......	36,290	549,109	101,295	124,838	715,542	75,757	1,062,831
9. York..............	24,804	393,346	38,661	143,508	446,765	42,451	1,089,535
10. Northern..........	13,282	240,865	35,853	82,488	207,784	32,160	612,442
11. Welsh.............	15,941	262,649	24,640	155,151	204,412	46,467	709,260
England and Wales	418,899	4,104,045	500,623	1,605,503	3,746,788	607,700	10,983,558

Divisions.	To every 100 persons, aged 20 years and upwards, of all occupations, the proportional number of each class. Classes. 1. Professional.	2. Domestic.	3. Commercial.	4. Agricultural.	5. Industrial.	6. Indefinite and non-productive.	Total.
1. The Metropolis....	5.9	41.1	8.4	1.6	36.1	6.9	100.0
2. Southeast rn.......	8.8	40.6	3.7	18.3	22.2	6.4	100.0
3. South Midland.....	3.2	35.0	2.4	24.4	29.1	5.9	100.0
4. Eastern............	3.4	38.8	3.2	26.6	22.3	4.7	100.0
5. Southwestern......	5.7	36.4	3.0	21.6	28.5	5.8	100.0
6. West Midland......	2.7	37.0	3.3	14.2	37.0	5.8	100.0
7 North Midland.....	2.4	35.0	2.3	21.5	34.5	4.3	100.0
8. Northwestern......	2.3	34.3	6.3	7.8	44.6	4.7	100.0
York..............	2.3	36.1	3.5	13.2	41.0	3.9	100.0
10 Northern..........	2.2	39.2	5.9	13.5	33.9	5.3	100.0
Welsh.............	2.2	37.0	3.5	21.9	28.8	4.6	100.0
England and Wales	3.8	37.4	4.6	14.6	34.1	5.5	100.0

The numbers in the last table represent *complete* divisions; as it was impossible, from the manner in which the census of occupations is compiled, to make the same adjustment in respect of the unreturned parishes as that effected for the first table. F. P.

Comparative statement of the number of paupers (except lunatic paupers in asylums, and vagrants) in receipt of relief on the last day of the first week of September, 1866 *and* 1867.

Divisions.	Year.	Number of paupers relieved.			Difference between the corresponding weeks.		Difference per cent.	
		In-door.	Out-door.	Total.	Increase.	Decrease.	Increase.	Decrease.
I. The Metropolis....	1866	29,758	76,906	106,664	10,319	....	9.7	....
	1867	32,054	84,929	116,983				
II. Southeastern......	1866	14,099	71,006	85,105	744	....	0.9	....
	1867	14,421	71,428	85,849				
III. South Midland....	1866	7,511	59,882	67,393	1,314	....	1.9	....
	1867	7,647	61,060	68,707				
IV. Eastern	1866	7,827	60,299	68,126	394	....	0.6	....
	1867	8,399	60,121	68,520				
V. Southwestern.....	1866	10,149	90,696	100,845	1,953	....	1.9	....
	1867	10,831	91,967	102,798				
VI. West Midland.....	1866	13,048	83,582	96,630	1,177	....	1.2	....
	1867	14,132	83,675	97,807				
VII. North Midland....	1866	5,579	44,317	49,896	494	....	1.0	....
	1867	5,802	44,588	50,390				
VIII. Northwestern	1866	17,660	69,460	87,120	3,517	....	4.0	....
	1867	19,172	71,465	90,637				
IX. York	1866	7,159	51,814	58,973	1,956	....	3.3	....
	1867	7,755	53,174	60,929				
X. Northern	1866	4,761	39,835	44,596	2,778	....	6.2	....
	1867	5,062	42,312	47,374				
XI. Welsh	1866	3,931	71,615	75,546	2,875	....	3.8	....
	1867	4,414	74,007	78,421				
England and Wales, (so far as returned.)	1866	121,482	719,412	840,894	27,521	....	3.3	....
	1867	129,689	738,726	868,415				

Comparative statement of the number of paupers (except lunatic paupers in asylums, and vagrants) in receipt of relief on the last day of the second week of September, 1866 *and* 1867.

Divisions.	Year.	Number of paupers relieved.			Difference between the corresponding weeks.		Difference per cent.	
		In-door.	Out-door.	Total.	Increase.	Decrease.	Increase.	Decrease.
I. The Metropolis....	1866	29,877	75,747	105,624	10,833	....	10.3	....
	1867	32,057	84,400	116,457				
II. Southeastern.......	1866	13,886	70,854	84,740	1,401	....	1.7	....
	1867	14,216	71,925	86,141				
III. South Midland....	1866	7,566	59,960	67,526	1,225	....	1.8	....
	1867	7,705	61,046	68,751				
IV. Eastern	1866	7,954	60,392	68,346	375	....	0.5	....
	1867	8,484	60,237	68,721				
V. Southwestern	1866	10,284	91,048	101,332	1,865	....	1.8	....
	1867	10,910	92,287	103,197				
VI. West Midland......	1866	13,127	83,697	96,824	1,142	....	1.2	....
	1867	14,095	83,871	97,966				
VII. North Midland....	1866	5,619	44,116	49,735	599	....	1.2	....
	1867	5,842	44,492	50,334				
VIII. Northwestern......	1866	17,883	69,445	87,328	2,994	....	3.4	....
	1867	19,122	71,200	90,332				
IX. York	1866	7,178	51,812	58,990	1,909	....	3.2	....
	1867	7,758	53,141	60,899				
X. Northern	1866	4,787	40,053	44,840	2,633	....	5.9	....
	1867	5,112	42,361	47,473				
XI. Welsh	1866	3,915	71,731	75,646	3,160	....	4.2	....
	1867	4,405	74,401	78,806				
England and Wales, (so far as returned.)	1866	122,076	718,855	840,931	28,136	....	3.3	....
	1867	129,706	739,361	869,067				

Comparative statement of the number of paupers (except lunatic paupers in asylums, and vagrants) in receipt of relief on the last day of the third week of September, 1866 *and* 1867.

Divisions.	Year.	Number of paupers relieved.			Difference between the corresponding weeks.		Difference per cent.	
		In-door.	Out-door.	Total.	Increase.	Decrease.	Increase.	Decrease.
I. The Metropolis....	1866	30, 105	75, 907	106, 012	10, 405	....	9. 8	....
	1867	32, 313	84, 104	116, 417				
II. Southeastern.......	1866	13, 921	70, 953	84, 874	1, 084	....	1. 3	....
	1867	14, 326	71, 632	85, 958				
III. South Midland....	1866	7, 718	60, 350	68, 068	1, 243	....	1. 8	....
	1867	7, 766	61, 545	69, 311				
IV. Eastern............	1866	8, 021	60, 816	68, 837	119	....	0. 2	....
	1867	8, 623	60, 333	68, 956				
V. Southwestern	1866	10, 427	91, 280	101, 707	1, 496	....	1. 5	....
	1867	10, 961	92, 242	103, 203				
VI. West Midland......	1866	13, 242	83, 520	96, 762	1, 294	....	1. 3	....
	1867	14, 135	83, 921	98, 056				
VII. North Midland	1866	5, 663	44, 072	49, 735	700	....	1. 4	....
	1867	5, 879	44, 556	50, 435				
VIII. Northwestern	1866	18, 026	69, 427	87 453	3, 511	....	4. 0	....
	1867	19, 281	71, 683	90, 964				
IX. York	1866	7, 186	52, 050	59, 236	1, 863	....	3. 1	....
	1867	7, 741	53, 358	61, 099				
X. Northern	1866	4, 742	39, 916	44, 658	2, 686	....	6. 0	....
	1867	5, 096	42, 248	47, 344				
XI. Welsh	1866	3, 956	72, 154	76, 110	2, 139	....	....	....
	1867	4, 413	73, 836	78, 249				
England and Wales, (so far as returned.)	1866	123, 007	720, 445	843, 452	26, 540	....	3. 1	....
	1867	130, 534	739, 458	869, 992				

***Comparative statement of the number of paupers (except lunatic paupers in asylums, and vagrants) in receipt of relief on the last day of the fourth week of September,* 1866 *and* 1867.**

Divisions.	Year.	Number of paupers relieved.			Difference between the corresponding weeks.		Difference per cent.	
		In-door.	Out-door.	Total.	Increase.	Decrease.	Increase.	Decrease.
I. The Metropolis....	1866	30,301	75,526	105,827	12,022	....	11.4	....
	1867	32,637	85,212	117,749				
II. Southeastern......	1866	13,945	70,573	84,518	2,283	....	2.7	....
	1867	14,516	72,285	86,801				
III. South Midland	1866	7,799	59,923	67,722	1,708	....	2.5	....
	1867	7,852	61,578	69,430				
IV. Eastern	1866	8,085	60,047	68,132	1,100	....	1.6	....
	1867	8,717	60,515	69,232				
V. Southwestern	1866	10,548	91,545	102,093	1,420	....	1.4	....
	1867	11,064	92,449	103,513				
VI. West Midland	1866	13,293	83,382	96,675	1,033	....	1.1	....
	1867	14,196	83,512	97,708				
VII. North Midland	1866	5,714	43,957	49,672	914	....	1.8	....
	1867	5,884	44,702	50,586				
VIII. Northwestern	1866	18,176	69,512	87,688	3,238	....	3.7	....
	1867	19,479	71,447	90,926				
IX. York	1866	7,248	52,139	59,387	1,954	....	3.3	....
	1867	7,771	53,570	61,341				
X. Northern	1866	4,759	40,131	44,890	2,373	....	5.3	....
	1867	5,107	42,156	47,263				
XI. Welsh	1866	3,997	72,259	76,256	1,715	....	2.2	....
	1867	4,398	73,573	77,971				
England and Wales, (so far as returned.)	1866	123,865	718,995	842,860	29,760	....	3.5	....
	1867	131,621	740,999	872,620				

APPENDIX K.

EDUCATION.

Returns for the years 1859–'66 of—

1. The number of grants made in each year for building, enlarging, or improving elementary day schools in England and Wales, in Scotland, and in Great Britain, with the total amount of such grants.

2. The number of schools inspected, distinguishing schools from departments of schools.

3. The average number of scholars attending the schools inspected and the number of scholars present on the day of inspection.

4. The number of certificated teachers acting in the schools inspected.

(Presented to both houses of Parliament by command of her Majesty.)

I.—ENGLAND AND WALES.

Year.	Years ending 31st December.				Years ending 31st August.								
	Grants for building, enlarging, and improving schools.				Number of schools inspected.						Number of scholars.		Number of certificated teachers acting in schools inspected.
	No. of grants.	Total amount.			Institutions.	Departments.							
		£	s.	d.		Boys.	Girls.	Infants.	Mixed.	Total.	In average attendance.	Present at inspection.	
1859..	434	124,820	9	10	5,531	2,024	1,958	1,280	3,021	8,283	674,602	757,072	5,225
1860..	388	111,274	14	2	6,012	2,162	2,048	1,414	3,388	9,012	751,325	830,971	6,342
1861..	310	92,293	4	0	6,259	2,162	2,014	1,537	3,604	9,317	773,831	879,884	6,758
1862..	223	58,389	17	0	6,113	2,090	1,924	1,526	3,533	9,073	790,056	889,994	7,465
1863..	163	34,425	1	11	6,188	2,430	2,120	1,511	3,171	9,232	825,691	911,287	7,875
1864..	129	25,329	12	6	6,428	2,039	1,750	1,448	4,028	9,265	828,946	955,179	8,587
1865..	101	17,759	13	0	6,815	2,211	1,787	1,605	4,336	9,939	860,370	1,042,766	9,429
1866..	120	23,250	2	5	7,081	2,243	1,841	1,651	4,550	10,285	871,309	1,086,812	9,905

II.—SCOTLAND.

Year.	No. of grants.	£	s.	d.	Institutions.	Boys.	Girls.	Infants.	Mixed.	Total.	In average attendance.	Present at inspection.	Number of certificated teachers
1859..	43	9,378	16	7	1,055	81	176	58	957	1,272	126,799	123,049	997
1860..	28	5,828	12	6	1,260	98	166	63	1,064	1,391	132,909	131,961	1,170
1861..	31	7,213	11	4	1,446	119	246	83	1,135	1,583	146,104	148,806	1,311
1862..	28	5,598	9	9	1,456	89	193	71	1,231	1,584	149,573	150,316	1,424
1863..	12	2,256	17	6	1,551	119	237	98	1,260	1,714	166.494	165,145	1,606
1864..	7	976	4	4	1,463	192	258	102	1,111	1,663	153,539	155,178	1,606
1865..	10	1,123	3	0	1,623	71	101	102	1,522	1,796	161,529	171,504	1,837
1866..	10	972	0	6	1,672	89	126	100	1,530	1,845	167,874	178,017	1,966

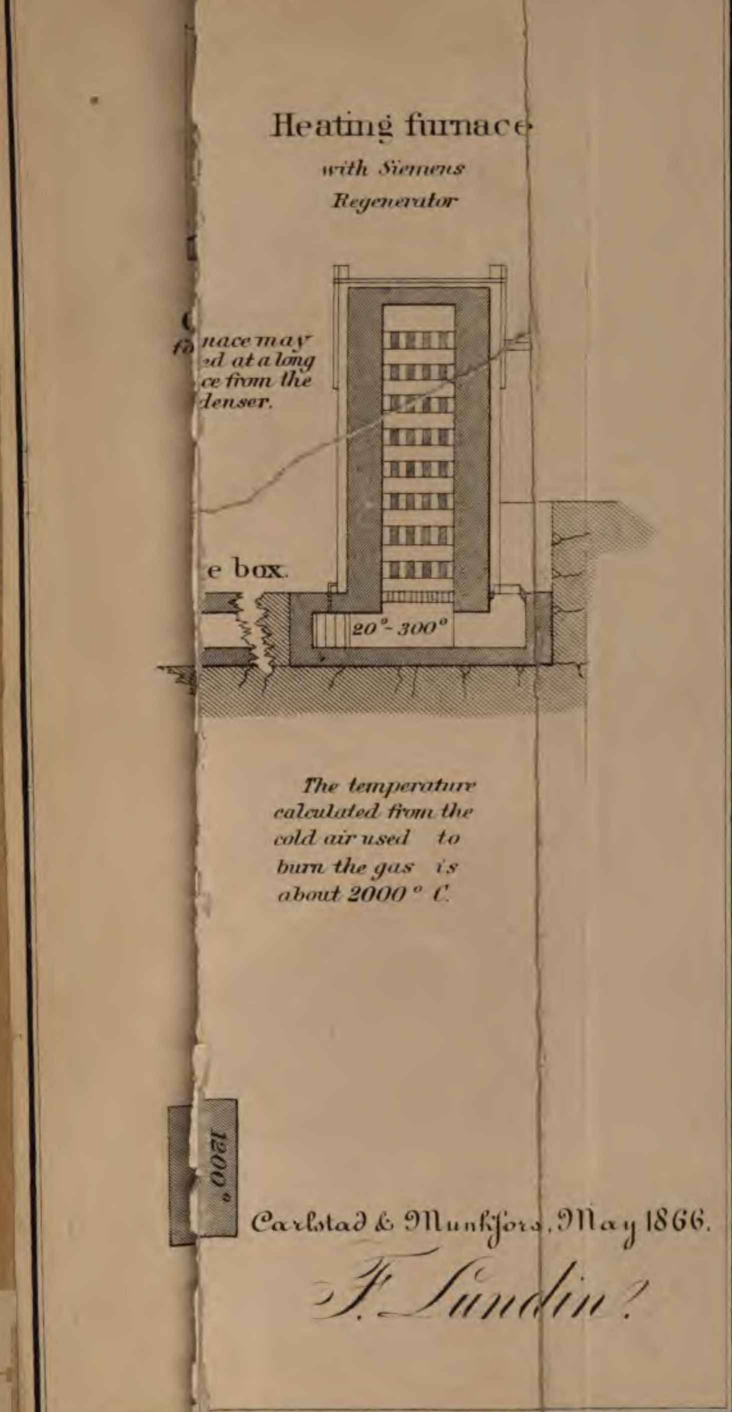
Returns for the years 1859–'66—Continued.

III.—GREAT BRITAIN.

Year.	Years ending 31st December.				Years ending 31st August.									
	Grants for building, enlarging, and improving schools.				Number of schools inspected.							Number of scholars.		Number of certificated teachers acting in schools inspected.
	No. of grants.	Total amount.			Institutions.	Departments.								
						Boys.	Girls.	Infants.	Mixed.	Total.		In average attendance.	Present at inspection.	
		£	s.	d.										
1859..	477	134, 199	6	5	6, 586	2, 105	2, 134	1, 338	3, 978	9, 555		801, 401	880, 131	6, 222
1860..	416	117, 103	6	8	7, 272	2, 260	2, 214	1, 477	4, 452	10, 403		884, 234	962, 932	7, 512
1861..	341	99, 506	15	4	7, 705	2, 281	2, 260	1, 620	4, 739	10, 900		919, 935	1, 028, 690	8, 069
1862..	251	63, 988	6	9	7, 569	2, 179	3, 117	1, 597	4, 764	10, 657		948, 629	1, 040, 310	8, 899
1863..	175	36, 681	19	5	7, 739	2, 549	2, 357	1, 609	4, 431	10, 946		992, 185	1, 076, 432	9, 481
1864..	136	26, 305	16	10	7, 891	2, 231	2, 008	1, 550	5, 139	10, 922		982, 485	1, 110, 357	10, 193
1865..	111	18, 882	16	0	8, 438	2, 282	1, 888	1, 707	5, 858	11, 735		1, 021, 899	1, 214, 270	11, 266
1866..	130	24, 222	2	11	8, 753	2, 332	1, 967	1, 751	6, 080	12, 130		1, 039, 183	1, 264, 829	11, 871

PARIS EXPOS[...]865.

Plate I.



Bowen & C° lith. Philad^a