

## EXCURSIONS.

The Excursions commenced on the afternoon of TUESDAY, 24th July, which was occupied in a visit to the works of the Society Cockerill, at Seraing. For a description of the works see below, p. 519. The members travelled in three parties, the first by steam tram to Seraing bridge, the second by train to Seraing station, and the third by steamer on the Meuse. This last party lunched on board the steamer, and the first two were successively entertained in the great hall of the chateau; the whole being by invitation of M. E. Sadoine, managing director. The following address was delivered in English by M. Sadoine, to the members of the first of these groups:—

GENTLEMEN,

On seeing before me so large a number of distinguished members of a friendly nation, I am reminded of the numerous ties that unite our respective countries; and my first impulse was to propose the healths of the two sovereigns who so happily direct our destinies. On second thoughts however, I reflected that we do not here tread on political ground, and that this assemblage has no official character.

I will therefore simply state that I am proud to see the Council of the Institution of Mechanical Engineers of England choosing Belgium this year as the place of their annual meeting. Here we have a new proof of those friendly bonds that unite us to Great Britain. I consider the choice made of Liège as a most happy one. In no other town are the interests of industry and science nearer to the hearts of the inhabitants.

We are not unmindful, gentlemen, of all that we, as a manufacturing and commercial nation, owe to England. May we not flatter ourselves that our own efforts in the same direction have had an echo across the channel, and that we may all be said to have contributed to the great work of progress and civilisation going on in the world?

In making you welcome, gentlemen, to the works founded by the illustrious John Cockerill, I am happy to have the honour of proposing your healths, and I drink to our still closer union under the glorious banner of science and industry.

The following address was also delivered by M. Sadoine, to the members of the second group :—

GENTLEMEN,

It is a great pleasure to me to offer you a welcome to Seraing. It is also a great honour to show to the sons of Old England the Works founded by one of their predecessors sixty years ago—works which the successors of John Cockerill have left and will leave under the shadow of that illustrious name. The name of Cockerill represents a tradition of science, of search after progress, of persevering work, of courage and energy in days of difficulty.

To remain faithful to the glorious traditions of the creator of Seraing, to develop continuously the great plant of this establishment, while watching over the welfare, the education, the morals of our excellent working population, is for us a duty. We shall not fail, for we have, to sustain us in our efforts, the motto of our great founder : “Courage to the last.”

In again bidding you welcome, I trust, gentlemen, you may be able to see whether we have fulfilled that duty or not.

After inspecting the works, the members returned by steamer from Seraing Bridge. The steamers were supplied free by the kindness of M. Ernest Orban ; as was also the train by the kindness of the Northern Railway of France, and the steam trams by the kindness of M. Dupont.

In the evening the summer Dinner of the Institution took place in the Salle de la Légion, Liège, the President in the chair ; and was largely attended, a number of distinguished Belgians being present as guests.

On the afternoon of WEDNESDAY, 25th July, three alternative Excursions took place. The first of these was to the Engine Works of the Ateliers de la Meuse (see below, p. 534), the Sclessin Iron Works (see below, p. 535), and the Horloz Collieries (see below, p. 530). The excursion was made by steam tram, provided free by the kindness of M. Dupont. At the Ateliers de la Meuse the party were received by M. Stévert, managing director; at Sclessin by M. Dallemagne, managing director; and at Horloz by M. Charlier and M. Braconnier.

The second Excursion was to the Angleur Steel Works (see below, p. 537); the Ougrée Blast-Furnaces and Collieries (see below, p. 538); and the Ougrée Iron and Steel Works (see below, p. 541). The trip was taken in a steamer on the Meuse, provided free by the kindness of M. Orban. At Angleur the members were welcomed by M. Galler, in the unavoidable absence of M. Rossius, managing director, and had the opportunity of seeing in successful operation the Thomas-Gilchrist or Basic process for the manufacture of steel. At the Ougrée Blast-Furnaces the members were received by M. L. Cheneux, managing director; and at the Ougrée Iron and Steel Works by M. A. Raze, managing director.

The third Excursion was to the Marihay Collieries (see below, p. 530), and to the Val St. Lambert Glass Works (see below, p. 544). The excursion was by special train, provided free by the kindness of the Northern Railway of France. The members were received at Marihay by the managing director, M. Dubois; and at Val St. Lambert by M. Jules Deprez, managing director.

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THURSDAY, 26th July, was devoted to two alternative Excursions; the one to the works of the Vieille Montagne Zinc Mining Company at Chénée (see above, p. 349), and to the Hasard Collieries (see below, p. 531); and the other to the Woollen Manufactories of Verviers (see below, p. 546).

The Excursion to Chénée was by ordinary train. The members were accompanied by M. Trasenster, and were received by M. St.

Paul de Sincay, managing director, by M. Vapart, and by the staff of the establishment. They were conducted through the works in groups, and were afterwards entertained at luncheon, when the following speech was delivered by M. St. Paul de Sincay :—

“GENTLEMEN,

“If I considered your presence here as a mere visit of curiosity, I should content myself with thanking you for the honour you have done us; but in this flattering manifestation of interest in Belgium, on the part of the *élite* of British engineers, I see a fact of more importance than a simple tourists' excursion; and I ask your permission to explain my meaning further. It appears to me, gentlemen, that your visit expresses a need which is felt, but has only lately been felt, by civilised nations—the need to see each other, to know each other better, to dissipate prejudice and error (those everlasting sources of division), to seek in a better appreciation of common interests, and in a more exact knowledge of facts, the true ground for mutual peace among the nations of the earth. Who could have predicted fifty years ago that two hundred leading engineers of the United Kingdom, representing one of the principal branches of British industry, would descend upon our soil as friends, and by their presence give a brilliant confirmation to the doctrine that the material interests of civilised nations are one?

“In former days manufacturers did not thus visit each other; or if they did they came in a totally different manner. They did not appear as friends to exchange ideas with one another; such visits as were paid were visits of war.

“A great change has now taken place; the brilliant discoveries which will make these ages famous for ever, such as the discovery of steam power and of electricity, have transformed men as they have transformed things. Fifty years ago, gentlemen, you would not have come, and I am not sure whether we should have received you; but to-day it is with the greatest pleasure we open our gates as wide as possible; we look on you not as enemies but as brothers in arms, fighting the same battle, and content that in this pacific

struggle the advantage should remain with the most energetic, the most worthy.

“England has been our great instructress in industrial matters, and especially in that queen of industries, the iron and steel trade; and we hope that the visit with which you have honoured us will leave in your minds the impression that Belgium, the pupil of your great country, has profited by the lessons she has received. Possibly you will find with us some things that are interesting and useful, some things which you may even be glad to learn. In that case all that we desire is that you should carry back to your great country the recollection of our cordial esteem, and of the pleasure it gives us to receive you. I ask you to drink to the union of the English and Belgian industries, a union of which your visit is the symbol and the witness.”

From Chénée a special train, provided free by the kindness of M. Jules d'Andrimont, took the members in the afternoon to the Bay Bonnet tunnel, where they were received by M. d'Andrimont, managing director of the Hasard Collieries, and where they visited the fuel works, coal-washing appliances, &c. From thence they walked to the workmen's town near Micheroux, which they inspected, and were afterwards entertained at a collation by M. d'Andrimont. They then returned by special train to Liége, and from thence proceeded by special train to Antwerp.

The Excursion to Verviers was by ordinary train. The members were received at the Verviers railway station by M. Mullendorff, President of the Chamber of Commerce, and by several other gentlemen of the town. M. Mullendorff welcomed the members, observing that Verviers possessed but one manufacture, that of wool, but that this could be seen in all its details. The party then proceeded to visit the Wool-Washing Works of M. Eugène Mélen, where they were received by the proprietor; the La Vesdre Wool-combing and Spinning Works, where they were received by the managing director, M. Math. Drèze-Rick; the Wool-spinning Works of M. Hauzeur-Gérard fils, where they were received by the proprietor;

the Wooller. Cloth Manufactory of MM. Peltzer et fils, where they were received by MM. Édouard and Augustus Peltzer; and the Wool-card Manufactory of M. Duesberg-Delrez, where they were received by the proprietor. (The above works are described below, see p. 546). They were subsequently entertained at luncheon by kind invitation of the Chamber of Commerce (President, M. Mullendorff; Secretary, M. Dückerts), at the hall of the Société de l'Harmonie. In the afternoon they drove in private carriages, kindly lent by gentlemen of the neighbourhood, to the Reservoir of La Gileppe (see below, p. 553), taking at first the route by Stembert (see Map of District, Plate 29), but returning by Limbourg and the Valley of the Vesdre. They then returned from Verviers by ordinary train to Liège, in time for the special train in the evening for Antwerp.

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On FRIDAY, 27th July, the members left the Town Hall, Antwerp, immediately after the reading of M. Royers' paper (p. 494), on a visit to the Docks, Fig. 1, Plate 51. They passed round the Great Basin, and inspected the working of the hydraulic machinery in the goods shed at its head. They then walked to the Kattendyk Basin, inspected the hydraulic engine-house, 120-ton sheers &c., and were conveyed by steamer across the basin to the new dry docks. They then witnessed the working of the great hydraulic drawbridge across the main entrance, and inspected the large pumping engines used for draining the dry docks. They next embarked on board the steamer "Télégraphe," which took them up the Scheldt to the Society Cockerill's dock-yard at Hoboken. Here they were received by M. Sadoine, junior, and saw two vessels on the stocks, both being built for the company, and also inspected the machine-shops and tools. Returning to the steamer, they were conveyed down the river to the yard belonging to Messrs. Couvreur and Hersent, contractors for the new quays. They were admitted under one of the great caissons, which had just been finished, and were there most hospitably welcomed by M. Hersent. The members then inspected the new hydraulic pumping station for the moving cranes, capstans, &c., on the new quays. These have compound

horizontal pumping engines of 400 horse-power, fed by tubular boilers, under construction from the designs of M. Matthys. The members then returned to the steamer, in order to go on board the movable cofferdam, which was engaged in setting one of the lengths of the new quay wall, as described above (see pp. 502-7). They then landed finally, and divided into several parties in order to inspect the Musée Plantin (which was kindly kept open for the purpose), and the Diamond-Cutting Works of M. Jean Coettermans and of MM. Kryn-Huybrechts et fils. In the evening the rooms and grounds of the Cercle Artistique et Scientifique were thrown open to the members. (For notes on the trade of Antwerp see below, p. 557).

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On SATURDAY, 28th July, alternative Excursions took place to Ghent, and to the Collieries of Mariemont. The members travelled to Ghent by special train, and were received at the Sud station by M. Braun, M. Henri de Brouckere, M. Galland, and others. Here they were divided into three parties. The first of these visited the Cotton Spinning and Weaving Works of the Société Ferdinand Lousbergs, M. Joseph de Hemptinne managing director. The second visited the Flax and Tow Mills of the Société La Liève, managing director M. Louis Desmet; and the third the Cotton Spinning Works of M. Jules de Hemptinne. The two latter sections then united, and proceeded to inspect the new Quay Wall, &c., at the Avant Port, under the direction of M. Deheem and M. Vanderlinden. The three sections afterwards united, and lunched at the Nursery Gardens of M. L. Van Houtte; after which they walked along the docks, examining the machinery and entrepôts, to the Locomotive Works of Messrs. Carels frères. (For notices of the above Works see below, p. 564).

In the other Excursion the members travelled by train to Mariemont, where, in the absence through illness of M. Guinotte, general manager, they were received by MM. Jean and Pierre Van Volxen, M. Briart, M. E. Peny, and others. They inspected the St. Arthur pit, and then walked to the Triage Centrale, or Central Screening Station, the arrangements of which were inspected.

Afterwards they were entertained at luncheon by the Mariemont and Bascoup Companies, M. P. Van Volxen presiding. Among others present were M. Guibal, inventor of the Guibal fan, and M. Coppée, inventor of the Coppée coke ovens and coal-washing apparatus. In the afternoon the members visited No. 5 pit of the Bascoup collieries, the largest and best equipped in the district; and then left by special train from Bascoup station to Manage, where they dispersed. (For description of the Collieries see below, p. 570.)

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## DESCRIPTION OF THE WORKS OF THE SOCIETY COCKERILL.

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ABRIDGED FROM A NOTICE PREPARED EXPRESSLY FOR THE MEETING,  
UNDER THE SUPERINTENDENCE OF M. E. SADOINE, MANAGING DIRECTOR.

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### I.—HISTORY.

Seraing is situated on the river Meuse, about six miles above Liège. It lies on the carboniferous formation, which enters Belgium by Hainault, traverses it from west to east, and leaves the Belgian frontier by Henri-Chapelle and Welkenraedt. This formation, lying from Charleroi to Namur in the valley of the Sambre, and from Namur to Liège in the valley of the Meuse, thins out in the latter district: the carboniferous limestone follows the left bank of the river as far as Flémalle; then dipping suddenly, throws up the coal-seams on the right bank more numerous, thicker, and richer than before. These beds underlie the whole of Seraing, where they were discovered about 1190.

At an unknown date the Princes of Liège built their summer palace at Seraing. It fell to ruins in the time of George Louis de Berg (1724), who restored, embellished, and enlarged it. It became national property when the Belgians passed under French domination, served as a military hospital, and was then transformed into a powder magazine. In 1815, on the foundation of the kingdom of the Netherlands, the palace and its dependencies remained the property of the Public Domain; which latter ceded it two years afterwards to James and John Cockerill, for the establishment of workshops for the manufacture of machinery, and for flax-spinning by the processes which they were then introducing into the country.

The establishment of Seraing was the development of the work done by Cockerill the father, at the Jesuits Bridge at Liège, from 1802 to 1813, and by James and John Cockerill after that date. The workshops at Liège had carried out work of immense magnitude

for those days, consisting chiefly of machinery for spinning wool and flax and for the operations of weaving.

Between 1818, the date of beginning work at Seraing, and 1823, when John Cockerill fixed his residence there, forty-three steam-engines had been made. They consisted of motors for spinning-mills, and of winding and pumping engines for collieries.

From 1824 down to the Belgian revolution in 1830, the number of steam-engines constructed amounted to 158, among them being one of 230 nominal HP. for the Royal Dutch corvette "Atlas." The circle of operations had extended. Blowing machinery, motors for iron-works, steam corn-mills, and especially marine engines, furnished the principal contingents.

The Belgian revolution of 1830 completely stopped this forward movement, by closing to the Belgian works the outlet of Holland.

From 1833 to 1835, quiet being re-established, 53 engines were turned out, of which two were for pumping (100 and 200 HP. respectively), and two were for boats (70 and 110 HP.) There were also two steamers. Besides this, the works had built for the Belgian State Railway the first large locomotive constructed on the Continent, and had rolled the rails it was to run on. The creation of railways made up for the outlets closed in 1830.

But the financial crisis of 1840, the death of John Cockerill, and the winding-up which followed, ending in the formation in 1842 of a limited company for the carrying on of the establishments, weighed heavily upon Seraing.

The production of the four years from 1840 to 1843 only rose to the same total as in 1839, that is, 24 stationary engines, 31 locomotives, 3 marine engines, and 3 steamboats; 1844 gave 12 stationary engines, 10 locomotives, 1 marine engine, and 1 steamboat.

In 1845 the movement was more considerable, and steady progress was made henceforward. In 1849, 1850, and 1851, 13 steamboats, besides 184 engines, left the Cockerill establishments. These engines included those sent to the Great Exhibition of London, which obtained the Grand Medal.

From 1852 to 1857, 236 stationary and marine engines and 150 locomotives left the Cockerill workshops.

From 1857 to 1865, 583 stationary engines, 206 locomotives, and 109 steamboats, among them being two ironclad gunboats for Russia, were produced. The machinery executed during this period comprised the boring machinery for the Mont Cenis Tunnel.

From 1866 to 1883, in its mechanical department, in bridge-building work, in boiler-makers' work independently of engines, and in ships and steamboats, the Society Cockerill has executed 22,670 orders for other countries. This includes seven new mail-boats (1866 to 1870) now running between Dover and Ostend; the first steamer built in Europe on the American system for the Volga; screw cargo-steamers, whose consumption of coal per indicated horsepower per hour is 1.55 lbs.; numerous blowing-engines (Seraing system); the mechanical plant of the steel works at the Ruhr, and at divers Russian works; the steel works of the *Compagnie des Forges de Châtillon et Commentry*, of the *Compagnie du Nord et Est de la France*, and those at St. Chamond and at Athus; bridges such as those over the Dniester, the Bug, and the affluents of the Volga; numerous apparatus for air-compressing and for rock-drilling; compound engines, reversing engines, winding and pumping engines; ironclad turrets, steel ordnance, &c.

Since 1866, the establishments of the *Société John Cockerill* have been managed by M. Eugène Sadoine, administrator-director-general. Under his direction have been carried out the development of the Colard Colliery, the acquisition of two-fifths of the concession of the coal mines of Espérance, and the acquisition of the Somorrostro iron mines in Spain; the creation of a fleet of sea-going steamers for the transport of iron ore by sea, and thence by canal; the blast-furnaces for making pig for the converters, and their connection, on the level of the upper platform, with the Appold coke-ovens at the Colard Colliery, as well as with the dépôt for ore on the top of the slag mountain (the latter being in connection, on the one hand with the Namur and Liège Railway, and on the other with the river Meuse, and accessible both ways by locomotives); the creation of a new foundry, of a new steel-rail mill, and of a reversing plate-rolling mill; the construction of the bridge-building shop and its annexes; the creation of the ship-building yard at Hoboken (Antwerp); the

refectories, workmen's houses, hospital, dispensary, and orphanage; the schools for adults and for colliers, the Naval Industrial School at Hoboken, &c.

## II.—DESCRIPTION OF THE WORKS.

On arrival by rail at the Seraing Station the visitor notices the Colard and Caroline Pits, and the Hospital and Orphanage erected by the Society in a salubrious situation, and surrounded by large gardens. The Hospital can accommodate 250 beds in the case of an epidemic, and all its arrangements are made for that number. In ordinary times forty to fifty wounded or sick patients are under treatment. Those in the employ of the Society, and their families, are admitted free, and those belonging to neighbouring works are admitted on payment.

The Orphanage accommodates 112 pupils of both sexes—children of the Society's workmen. They there receive primary instruction, and lessons in gymnastics and music. At fourteen years of age, the boys are admitted into the works as apprentices, the girls continue as seamstresses or washerwomen as they may be taught.

From the station, the Colard Pit is reached by ascending an inclined plane, at the foot of which, in buildings belonging to the Society, are installed the preparatory classes of the Miners' School, and the school itself. The preparatory classes take children and youths from twelve to sixteen years of age, and the Miners' School is for training head miners, and mining inspectors.

To the east of the inclined plane is a dispensary, belonging to the Society, from whence medicines and necessaries are distributed gratuitously.

*Colard Pit.*—This contains two shafts of a depth of 530 metres (579 yds.), from which 2000 tons of coal may be raised daily; 5000 cubic metres of water may be pumped out in the same time (1,100,000 gallons).

The winding engine, using a steel-wire rope on a spiraloidal drum, is of more than 1000 HP. net. No other of the kind exists in Belgium.

The two rotary pumping engines, of the type invented in all its

parts by the Society Cockerill, exert 250 HP. each, in water raised, and are similar to those exhibited at the Paris Exhibition in 1878.

The Society's coal is rich, and suitable for the manufacture of coke, and for the requirements of metallurgical establishments. The concession comprises 307 hectares (758½ acres). There are 432 Appolt coke-ovens dependent on these collieries, which produce 360 tons of coke of the best quality per diem. The total coal used in the works is about 1400 tons per diem.

*Slag Mountain.*—On the inclined plane leading to the pit there is a line of rails 1½ metre gauge, for locomotive and coke wagons; and a double line of narrow gauge, worked by an endless chain coming from the pits, and bringing coal in small trucks for the supply of the furnaces. Towards the middle of the inclined plane in question, is a branch line leading to a number of other inclined planes, arranged spirally around the sloping sides of the artificial mountain, created since 1820 by the continued deposits of shale, slag, scoriæ, and rubbish. They run up to the top of the mountain, which is levelled to form storage-room for the materials (ore, flux, and coke) necessary for the supply of the blast-furnaces.

This mountain, enclosed, so to speak, in the middle of the works, occupied very valuable ground, and its encroachments every year became more and more serious, more especially as the increase of the blast furnaces and steel works required so much more room for the transport and reception of their materials than heretofore.

In 1879 it became necessary to re-arrange communications; and the transformation of the slag mountain, to form a platform for the storage of materials for the blast furnaces, was resolved upon.

It was an important work, as much from the difficulties encountered as from the results to be obtained; the surface occupied by this mountain is considerable, and its height extends 35 metres (115 feet) above the level of the Meuse.

Leaving the aforesaid platform, and following the curves of the railway round the mountain, the Gas Works are passed, where gas is made from the refuse of petroleum,\* and then we come to the

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\* The installation of these gasworks has been of great service to the fitters and workmen employed, the light given by petroleum gas being more brilliant and more steady than that from ordinary coal gas, which tires the sight.

Caroline Pit, with its groups of Coppée coke-ovens, recently acquired by the Society. Further on, and coming to level ground, the road follows the banks of the Meuse through the different stores for steel rails, timber for the pits, iron from the rolling-mills, and especially for the Algerian and Spanish ores, which come from Antwerp by canal. Powerful steam elevators, erected in 1873 on the crest of the river bank, enable the ore to be quickly unloaded. The ore also comes by railway, paying to the State more than a million francs annually for carriage. On arriving at the Seraing railway station, these ore trucks are taken by the Company's locomotives towards the dépôt on the top of the slag mountain. If brought by water, the ore is lifted by the elevators and deposited either in iron enclosures stretching alongside the Meuse, or in tip-wagons by which it is taken to the stacks established on the slag mountain.

Nearly in front of the elevators are a third set of coke-ovens (Appolt system), which produce 140 tons of washed coke daily. Close by is the canal, by which barges bring ore, &c., to the basin in the interior of the works. By the side of this canal are to be found the pattern store, the delivery store, the general store, and the timber store. There is a yard for building iron river-boats, installed on the bank of the river; and there are also enormous dépôts of timber of different sizes for the coal-pits, stores for the products of the rolling-mills and steel-works, &c.

*The Castle of Seraing.*—This comprises the residence of the Director-General, the Library, the Archives, the chamber reserved for the general meeting of shareholders (where in olden times the States-General of the Prince Bishop of Liège held their sittings), &c. A large building on the other side of the courtyard contains the office of the Secretary-General, the commercial and industrial offices, and that of the Chief Engineer, &c. Beyond this extend on one side the drawing offices, under the immediate direction of the latter, who has between forty-five and fifty engineers, draughtsmen, and tracers under him; on the other side are the Board and Committee-rooms of the Council of Administration and the office of the Director-General; then come the pattern shop and photographic studio.

*Fitting Shops.*—Workshop No. 1 was built in 1871. The roof on the “Raikem” or saw-tooth system has since been copied by the State and by the Northern Railway Company. It had not been used till then except for spinning mills. It presents the advantages of an equal distribution of light and air in every part, which is very advantageous for fitting work and for the health of the workmen.

The buildings forming the left wing enclose the Pattern shop, established in 1872, which is shop No. 2. Workshop No. 3 has been enlarged and rearranged successively in 1879 and 1881. Workshop No. 4, or the locomotive shop, was enlarged and modified in 1864. In Workshop No. 5 the large land and marine engines are erected. This building is lighted by night by the electric light, which is very favourable for erecting work. Workshop No. 6 is the bolt and nut making department.

The lifting cranes in the workshops are all worked by compressed air. A large 50-ton travelling crane is placed in the yard for handling and loading up heavy goods, such as locomotives.

*Marie Pit.*—This colliery, now in the middle of the works, was started in 1856, the pits being sunk by compressed air. Here was established in 1875, for the first time in Belgium, a system of central condensation of the steam from the various motors by means of a special condenser and air-pump. The plant comprises an air-compressing engine, first put down in 1871 to work the drills at the Caroline and Colard Pits. The centrifugal ventilator was erected in 1878, and is the first of the kind.

*Forges.*—This division contains a steam-hammer of 25 tons, erected in 1877, capable of forging cannon in steel of the largest calibre. There are also other hammers of less importance.

The small forges comprise hammers for the manufacture of wheels for locomotives and railway wagons, &c., and a lathe-shop for rough-turning these forgings. A large dining-room, with white marble tables, is placed between the hammer-shop and forges. Similar rooms exist in all departments for workmen who do not live in Seraing. They date from 1866, after the cholera epidemic.

*Boiler Department.*—All that remains of the old boiler-shop are the two large shops for the erection of boilers. The shop for plate-

flanging, and for the preparation of other parts of boilers, was erected in 1874. The large bridge-building shop and its annexes have been erected since 1880.

*Blast-Furnaces.*—Two of the three old furnaces make pig-iron from Luxembourg ore. The third makes hematite pig from Spanish and Algerian ores for the converters, as do also the four new furnaces at the Steel Works. They produce on an average about 50 tons of pig a day.

The large horizontal blowing engine, dating from 1860, was transformed into a compound engine in 1880; its power is from 270 to 300 HP.

These furnaces will probably be connected with the upper ore platform, similarly to those at the steel department; and the Luxembourg ore arriving by railway will be brought on to the platform in close proximity to the mouths of the furnaces.

The inclined planes used for elevating the slag and scorix from the iron mill were made in 1875.

*Steel Works.*—In 1866 these only comprised one 5-ton converter, and a rolling mill for rails and tyres; all the rest of this department has been constructed since 1866. The old foundry is transformed into a Siemens-Martin furnace shop. Of the four blast-furnaces alight, Nos. 1 and 2 were erected in 1871–72. They were rebuilt in 1881, and raised to the same height as Nos. 3 and 4 constructed in 1880–81. These four furnaces produce each 70 tons of pig for steel-making daily; and the metal can be run direct from them into the converter. The consumption of these furnaces in foreign ore is 180,000 to 200,000 tons, and the production of pig about 100,000 tons per annum.

The three large blowing-engines, which supply them with air, have a collective power of 600 HP. Two are sufficient for four furnaces, the third is held in reserve. They are of the type invented by the Society Cockerill, and used all over the world. Nearly 160 of these engines have come out of the Seraing workshops.

The Bessemer foundry contains four converters. The last pit is capable of producing by itself 300 tons of steel per diem. The Bessemer blowing engines are also on the Cockerill system. The

rail mills (roughing down and finishing) produced in 1878 as much as 2054 tons of rails in five days' work. The direct-acting reversing gear is the invention of the Society; its promptness of action is remarkable.

The tyre mill is able to roll tyres of nearly 2 metres diameter ( $6\frac{1}{2}$  ft.), as well as ordinary sizes. It is by means of these powerful tools that the Society have been able to roll the large hoops required for guns, as furnished by the Society to the Italian, Dutch, and Belgian governments.

The steel works employ about 1540 workmen.

*Foundries.*—This department is composed of three large buildings, of which the two principal ones have been built since 1866, in strict accordance with all rules of health and convenience applicable to the moulders' industry: they are provided with ample means of transport and lifting, which allow of a considerable reduction in cost price. Since 1866 the Brass Foundry, Sand Store, Core-makers' shops, &c., have also been erected on the west side of this department.

*Iron Works.*—This division is perhaps the one that has undergone the least change since 1866. Nevertheless important improvements have also been made here. Dating from 1868, all the motors have been fitted with condensing apparatus; and boilers heated by coal have disappeared, steam being produced by the waste heat from the puddling and reheating furnaces. A train of rolls for large bars and rolled girders, with an engine of 280 HP., has been added; and the plate-mill, having become obsolete, has been altered and attached to a powerful reversing engine (the first on the Continent) of 550 HP., constructed in the works in 1868. A new plate-mill is in course of construction. The different buildings have also been renewed, and steam-hammers of the best system have replaced the old tools.

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## NOTES ON COLLIERIES VISITED AT LIÉGE.

The following notes on collieries visited in the course of the meeting at Liège were kindly prepared by Mr. Edgar P. Rathbone, of Westminster, F.G.S., Assoc. Inst. C.E.

## COLLIERIES OF THE SOCIETY COCKERILL.

The collieries belonging to this company are situated on the works at Seraing, the finest of them being sunk on the ground immediately at the back of the blast furnaces.

There are three collieries in all, viz.: the "Marie," "Colard," and "Caroline." The last two are working at a depth of 525 yards from the surface.

The Colard Pit has been laid out in the most complete style, the plant being capable of raising 300 tons per day of ten hours from a depth of 750 yards.

The winding engine, which is of horizontal type and of American build, is fitted with the Society Cockerill's variable expansion gear, and has a spiral drum, the rope of which is made with a uniform decreasing section. The correct position of each spiral on this drum has been so carefully calculated that an almost perfect equilibrium has been obtained, and the drum works with scarcely any vibration or oscillation.

The iron head-gear is of simple and light construction, and is enclosed in a building, as is the custom on the Continent. The guide-rods are of wood, of a special design by M. Charles Lambert.

The shaft is 15 feet in diameter, and is divided into three compartments, of which two are for winding; the third, in the form of a half moon, being set apart for the pumps and ladders; and there is a small winding-shaft with a cage for the examination of the pumps, &c.

The pump is a rotary force-pump, double-acting, with condensers of the Rittinger type; it is worked expansively with a cut-off at

3-16ths of the stroke. It lifts 220,000 gallons per 10 hours. In the same house is a small capstan-engine for the service and pump repairs. The shaft is fitted with an iron lining in the upper part, in place of masonry.

The ventilation of the collieries is effected by six ventilators. At the Colard and Caroline pits they are of the old Fabry type. At the Caroline pit there is also a Guibal fan of the ordinary construction, and at the Marie pit a new form of turbine ventilator. This fan, designed by M. Kraft, is stated to be capable of exhausting 50,000 cubic feet of air per minute with 3-inch water-gauge. In this fan the air is conducted into a circular apparatus constructed much the same as a turbine-case, and certain fixed and curved vanes (*directrices*) guide the air into the blades of the revolving crown of the fan in such a manner that shocks and baffling of the air are greatly reduced, the air passing into the blades of the fan with very little friction. The blades of the fan likewise are so curved that the air is obliged to fill completely all the openings between them; this also has the effect of diminishing irregular movements in the fluid current. On leaving the revolving crown the air still possesses a considerable velocity, the useful effect of which would be lost, if it were allowed to escape in this condition. In order to avoid this loss, the revolving crown is surrounded with another apparatus called the "diffusor," which presents a large area for the air to escape by, and thus diminishes the final velocity of the escaping current.

The whole fan is supported on a cast-iron column or pedestal 6 feet in diameter, which serves at the same time for conducting the air current into the fan from the drift leading from the shaft, and as a support for the small vertical engine which drives the fan. This engine consists of a small pair of vertical cylinders, bolted on to a bed-plate which is fixed directly to the side of the pedestal. The motion is transmitted to the fan by spur-gearing.

The manufacture of coke in Belgium has received much scientific attention, and many systems hardly known in England are in use there, such as the Appolt (well exemplified at the Society Cockerill's Works), and the Coppée, Smet, and Dulait.

The Appolt oven, although very costly in first construction, presents many advantages, especially great working capacity, economy in maintenance, &c. It is also considered most suitable for particular classes of Belgian coking coals.

#### HORLOZ COLLIERY.

The Horloz Colliery is typical of a colliery well laid out according to local conditions; it is economically managed, and has been a great financial success. There are some novel appliances at work: namely a Goffint ventilator, an air-compressor of the same type as that used so successfully in the works of the Arlberg tunnel, and a winding engine drawing from the ventilating shaft.

The Goffint fan has been described, and compared with other fans as to its efficiency, in a Report on Mechanical Ventilators prepared for the North of England Institute of Mining and Mechanical Engineers, vol. xxx., 1881, page 285.

#### MARIHAYE COLLIERIES.

Vieille-Marihaye Colliery consists of three shafts, two for winding and pumping and one for ventilation only. The Pierre-Denis shaft is about 600 yards deep, with a diameter of 13 ft. The cages are fitted with Libotte's parachute, as a precaution against accidents from the rope breaking. The winding ropes are flat, and of aloe or Manilla fibre, as is usual at most collieries in Belgium. The average output is about 500 tons for a day of ten hours. The winding engine is of the vertical type, with 2 ft. 6 in. cylinders and 5 ft. 6 in. stroke. The ventilation is effected by means of four Fabry fans, 5 ft. radius and 10 ft. broad, exhausting 85,000 cubic feet of air per minute with  $1\frac{1}{2}$ -inch water-gauge. They were made by the Ateliers de la Meuse Society.

There are two machines for supplying compressed air for the rock-drills in the mines, one of the Sommeiller type and the other of the Dubois and François. A large quantity of the coal raised has to be carefully screened and washed; and for this purpose there is a peculiar kind of vibrating screen which is said to do good work. The system of coal-washing is that of M. Bérard, which is well

exemplified at these collieries. There are over 100 coke ovens, all built on the Smet system. The system of endless-chain haulage is employed for transporting the coal from the shaft to the screens.

Nouvelle-Marihaye Colliery consists of two elliptical shafts, each divided into two separate compartments. The output here is over 300 tons per day of ten hours. The winding engine is vertical, with cylinders 2 ft. diameter and 5 ft. stroke.

Underground at these collieries a considerable amount of work has been done in driving stone-drifts with the Dubois and François rock-drill. In one stone-drift, the face of which had an area of 54 sq. ft., the drill advanced at the rate of nearly 6 feet per day of twenty-four hours, the rock being of a hard slaty character.

#### HASARD COLLIERIES, NEAR MICHEROUX.

This Company has a concession of over 4000 acres.

The discovery of this part of the Liège coalfield was due to a prospecting tunnel or level, known as the Laid Broly. This level, after being driven a distance of over 1800 yards, met, in January 1851, with an excellent seam of coal about three feet thick.

In 1857 the level known as Bay Bonnet was begun, but it took thirteen years to drive the whole distance of about 3500 yards. It has an average section of 10 ft. by 7 ft., and is used for bringing out the coal. The system of endless-chain haulage which is employed for this purpose appears to give every satisfaction. The power for the haulage is obtained from a horizontal engine of 100 HP., worked expansively, and with a condenser. At the same time that the level was being driven a shaft was sunk on it 130 yards deep, and from this shaft coal is also drawn. The Company has made rapid progress since the tunnel was completed, and at the present time may be counted as one of the largest and most influential enterprises in Belgium.

As the collieries are situated at some distance from any town or village, the Company have been obliged to build a small mining village for their workmen, which is of a model character. They have also built a large workmen's lodging-house, called the Hotel Louise, which cost, completely furnished, £7500, and will lodge 200

workmen, the cost of board and lodging per man being only 1s. 3d. per diem. Breakfasts and suppers are supplied at 2d. per meal, and dinners for 4½d. The Company became so well satisfied with the working of the Hotel Louise, that in 1874 they decided on building a second one large enough for 180 workmen.

These workmen's lodging-houses are well worthy of a visit, the arrangements for cooking and for washing the colliers' clothes being particularly well carried out.

*Air-Compressors.*—These are of the Sommeiller type, met with everywhere in Belgium.

*Ventilation.*—This is supplied by Guibal fans of the ordinary type and construction.

*Mechanical Screening Arrangements.* — The coal-screening arrangements at the Hasard Colliery are of the most interesting and instructive character; they are the invention of MM. d'Andrimont and Julian Léonard. The following is a brief description of their working. The coal, arriving in tubs or pit-wagons at the screening sheds, is tipped by automatic tiplers over two of M. Briart's screens with movable bars.\* These screens separate the coal into two classes, ("Gaillettes" or large coal, and small coal), over and under 2½ in. diam. respectively. The smalls pass directly into hoppers, with sloping bottoms, so that the coal slides naturally into two bucket elevators, working at the lower end of the hoppers. These elevators deliver the coal into two cylindrical revolving screens, made with a double cylinder, one inside the other. The smalls are further separated by these revolving screens into three classes or sizes: namely, 2 in. diam. or "Gailletins," 1 in. or "Petits Gailletins," and under 1 in. or "Menu," the smallest size, used for making patent fuel. This small coal is first washed in a machine invented by M. Bérard, and then passes into a large hopper capable of holding 15 tons, from which it is run out into wagons and taken to the briquette or patent-fuel works.

The largest size of the small coal, or "Gailletins," passes out of the end of the inside frame of the screen on to an endless travelling

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\* See description of Mariemont Collieries, *infra*, p. 571.

band, at the side of which women or boys stand and pick off the dirt. These bands, which run on iron rollers, are made of strands of aloe-fibre, and are provided with a tightening apparatus.

The bands deliver the coal on to two platforms, the floors of which are also fitted with a screen of fine mesh, so as finally to separate any small coal. The platforms also are so arranged that the coal upon them may be lowered into the trucks below, without being subjected to any further rough handling.

The "Petits Gailletins," or medium-size small-coal, passing out of the end of the outside frame of the revolving screen, is delivered similarly on to endless travelling bands, where it is cleaned. If the consumer desires it, he can have these coals washed, in which case they are conducted by another endless band, first into a small screen with fine mesh and percussive motion so as to separate the dust, and then into a coal-washer of the Bérard type.

The large coal, or "Gaillettes," passing over the Briart screens, falls on to percussion frames, by which means it is jogged forward, without much shock, on to endless bands, where the dirt is picked out, the coal being separated also by hand into different sizes. The bands deliver the coal into iron shoots fitted with movable spouts, so that the coal can be charged into any part of the railway truck, with the least possible amount of breakage. The very large lumps or best coals are separated out by hand from the "Gaillettes," and placed upon another endless band, which transports them into shoots similar to those just described.

It is estimated that the two revolving screens together screen 400 tons of coal per day of ten hours, and produce 40 to 50 tons of "Gailletins" and 60 to 70 tons of "Gaillettes" or large coal. The motive power for all these screening arrangements is derived from a pair of small horizontal engines of 30 HP.

## WORKS OF THE ATELIERS DE LA MEUSE.

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(NOTE SUPPLIED BY THE MANAGING DIRECTOR, M. A. STÉVART.)

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This Company (La Société des Ateliers de Construction de la Meuse) was founded on January 1st, 1873, succeeding to the firm of Charles Marcellis, whose works were at Boverie-lez-Liège. On 1st November in the same year the works were transferred to Val-Benoît, where they occupy altogether a space of 50,000 square metres (12 acres). The workshops, properly so called, cover 12,500 square metres (3 acres) and form a single block in one continuous length of 245 metres (270 yards).

The firm of Charles Marcellis was founded in 1835. Amongst the most important productions of the first year after its establishment may be mentioned numerous roofs and bridges in iron; and later, steam engines and mechanical appliances of all kinds, as well as railway plant. At present the winding engines, pumping engines, and ventilating engines of the firm are to be seen in almost all the important collieries of the Liège district, and in other coalfields both in Belgium and abroad. They are also to be found in metalliferous mines of the highest importance, such as those of Bleyberg, those of the Vieille Montagne Company, both in Belgium and abroad, those of Le Rocheux, of Velaine, of Lintorf in Prussia, of Monteponi in Sardinia, and of Linares in Spain.

The Company also constructs engines and appliances for metallurgical works, for blast-furnaces, iron and steel works, &c.; marine engines and hulls of boats (for which there is a special shop), steam dredges and marine boilers; hydraulic plant, including motor engines, accumulators, and cranes; sugar mills; and lastly all kinds of articles relating to mechanical construction, carpentry, boiler making, and iron founding.

## DESCRIPTION OF THE SCLESSIN WORKS.

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[Abstracted from a pamphlet by M. JULES DALLEMAGNE, Managing Director.]

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The Society was started in 1828, simply to work the colliery of Bois d'Avroy. They gradually acquired other collieries and iron mines, and became successively makers of pig iron and of wrought iron, especially rails and girders. The latter trade gradually became the principal one; workshops were built, and the collieries were some of them formed into distinct companies. Their present undertakings may be described as follows:—

1. Iron mines near Athus in Luxembourg supplying about 300 tons of ore per day, and a mine at Couthuin supplying about the same quantity. The latter is connected with the Meuse by an adit, through which the ore is brought out and loaded direct on to barges, or on to the trucks of the Northern railway.

2. The colliery of Bois d'Avroy, having two pits, and yielding about 300 tons per day from each.

3. Two blast-furnaces, utilising the whole of the ore supplied from the mines. They are built on pillars, according to the most recent system, with open hearth; their height is 20 metres (66 ft). The gas is taken off by a single opening in the side of the furnace. The blast has a temperature of 650° to 700° C. (1200° to 1300° F.), and is supplied by four Whitwell stoves to each furnace. There are three blowing engines of the Woolf compound system, and with condensers, each having a power of 100 HP. Each furnace produces per 24 hours 100 tons of white finery iron, consuming 98 to 100 tons of coke and 300 tons of ore. The ore used comes from the Jurassic beds of Luxembourg, and from calcareous specular beds at Java near Huy, in the carboniferous series. The ore is brought by railway direct to the mixing sheds, where it is discharged, broken up, and loaded into tipping wagons to be conveyed to the lift. Part

of the furnace gases are used to heat ten horizontal boilers, which supply steam to the works.

4. Coke ovens, 108 in number, of a horizontal kind peculiar to these works. The coal used comes partly from the Society's colliery and partly from elsewhere.

5. A foundry, with two cupolas and a steam lift. It is chiefly used for the articles required in the machine shops and rolling mills of the works.

6. Gas works, in three groups, each containing seven fire-clay retorts, and each distilling 45 kilos (100 lbs.) of coal per hour.

7. Rolling mills, comprising thirty puddling furnaces, and thirteen heating furnaces; also thirty-five boilers, heated by the waste heat, and supplying steam to fifty-two steam engines of 1500 HP. total. There are ten trains of rolls, two being for roughing down, one for scrap, one for plates, three for merchant iron, and three for girders, &c. The total production is 30,000 tons per annum in girders, angles, tees, and other special sections, as well as merchant iron and plates. The finished iron is loaded on wagons running upon a sunken railway, so as to give no trouble in lifting.

8. Machine shops. These commenced work about 1860, chiefly in making girders and bridges. In 1874 the ironwork for the Syzrane bridge over the Volga (the longest in Europe, being 4730 ft. long, and weighing 7500 tons) was constructed here. The shops comprise forge, boiler shop, erecting shop, and open yard for large bridges. In addition to girder work they supply railway plant, such as traversers, two of which, for locomotives and worked by steam, were in hand at the time of the visit. The total production is from 6000 to 8000 tons per annum.

The Society possesses several institutions for the benefit of the workmen, such as schools, containing more than 800 pupils, a sick club, pension club, musical club, &c.

## DESCRIPTION OF THE ANGLEUR STEEL WORKS.

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BY M. ROSSIUS, MANAGING DIRECTOR.

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The Society manufacture steel by the Bessemer process, in all qualities from the softest to the hardest. The metal is not run direct from the blast-furnace, but is remelted. There are six converters, of which four of 6 tons each are employed on the Thomas-Gilchrist process, and two of 7 tons each on the ordinary Bessemer process. There are two blowing engines with separate condensers, two hydraulic accumulators, nine hydraulic cranes &c. There are seven steam hammers, the heaviest being of 15 tons. The rolling mill comprises:—(1) A three-high train of rolls 0·65 m. diam. (26 in.), driven by a vertical condensing engine, cylinder diameter 1·15 metre (46 in.), stroke 1·4 metre (56 in.); (2) A three-high train for billets and rails, driven by a vertical engine, cylinder diameter 1·00 metre (39 in.), stroke 0·80 metre (33 in.); (3) A train for spring steel &c., driven by a vertical engine, cylinder diameter 0·65 m. (26 in.), stroke 0·90 m. (36 in.); (4) A horizontal tyre-mill. There are the ordinary appliances, such as saws, straightening and bending presses, drills, &c. At Renory the Society possesses also a wire mill with a roughing train, finishing train, &c. They also own coke-ovens at Tilleur near Liège, and two blast-furnaces at Audun-le-Tiche in Lorraine. These furnaces supply a part of the pig iron for the basic process. The ore is derived from mines owned by the company. The production of the company consists chiefly of rails, tyres, both for locomotives and wagons, railway springs, steel castings, and steel forgings.]

## DESCRIPTION OF THE BLAST-FURNACES AND COLLIERIES AT OUGRÉE.

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SUPPLIED BY THE KINDNESS OF THE MANAGING DIRECTOR, M. L. CHENEUX.

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*Blast Furnaces.*—These are four in number, of which three have been rebuilt one after another since 1878. They are 17 metres high (55·8 ft.), and 5·25 metres (17·2 ft.) in diameter at the boshes. Their interior capacity is 246 cubic metres (8700 c. ft.). The daily make of each furnace is, in round numbers, 60 tons. The make from two furnaces, during the business year 1881–1882, was 41,000 tons. The qualities are the following :—

- (1) Strong white pig.
- (2) Spiegel pig for fine-grained or Best-Best iron.
- (3) Bessemer pig.
- (4) Pig for the Basic process.

The ores used for ordinary puddling pig come from the province of Namur and from Luxemburg; those for steel pig are imported from Germany, Spain, and Greece. The coke is produced in the Society's own ovens: the flux comes from Chokier, in the province of Liège. The throat of the furnace is open, and the gases are taken off by a central flue, having in two of the furnaces a diameter of 1·80 metres (5·9 ft.), and in the other two of 2·50 metres (8·2 ft.). In the third furnace the gas is deprived of its dust by circular "washers" placed round the furnace. This gas suffices for heating the air, and for producing the steam required to work the lifts, the blowing engine, and the accessory engines.

The blast is heated by fire-brick stoves on the Whitwell system, four to each furnace. Their height is 13·2 metres (43·3 ft.); diameter 5·5 metres (18 ft.); and the temperature of the air 550° C. or 1000° F. The blowing engines are three in number: two of them are beam engines on the Evans system, with a blowing cylinder 1·80 m. in

diameter (5·9 ft.), and 2·4 metres stroke (7·7 ft.). The third engine is of the Seraing type, with a blowing cylinder 2·65 m. in diameter (8·7 ft.) and 2·4 m. stroke (7·7 ft.). Steam is generated by seven boilers on the Jumeli system, tested to 5 atmospheres (75 lbs. per sq. in.). Each boiler is composed of two shells 0·9 m. in diameter (2·95 ft.), and 12 m. long (39·37 ft.). Each of these has below it a heating tube 0·70 m. in diameter (2·3 ft.), and 10·50 m. long (34·4 ft.). The two shells are independent of each other, and merely have the fire in common.

*Coke Ovens.*—Since 1871 the Society has by degrees replaced all its horizontal ovens by ovens on the Appolt system. It now possesses ten sets of these ovens, each having eighteen compartments, and each producing  $16\frac{1}{2}$  tons of coke in the 24 hours. The total production for the commercial year 1881–82 was 55,000 tons. The proportion of coke yielded was 80 per cent. of the original coal, which contains 17·5 per cent. of gas, and which if burned in the raw state gives 18 per cent. of ash. The preparation of the coal consists in screening it to three different sizes, with the following results:—

(a) 41 per cent. of small coal, less than 6 millimetres ( $\frac{1}{4}$  inch) in diameter, and giving 7·8 per cent. of ash.

(b) 22 per cent. of large coal, above 35 millimetres in diameter (1·4 in.), and giving 13·1 per cent. of ash. After hand picking, to get rid of the stone, the proportion of ash falls to 4·8 per cent.

(c) 37 per cent. of rough slack between 6 and 35 millimetres in diameter, and containing the greater part of the stone. This coal contains 20·4 per cent. of ash, but after washing this is reduced to 5·2 per cent.

The three sizes are subsequently brought together, crushed, and mixed: the mixture contains 7·5 per cent. of ash, and the coke contains 9·5 per cent. This preparation has amongst other results the effect of reducing by 35 per cent. the proportion of phosphorus existing in the coal, and by 50 per cent. the proportion of sulphur. The coke contains 0·033 per cent. of phosphorus, and 0·2 per cent. of sulphur.

*Collieries.*—The collieries at Ougrée have an extent of 378 hectares (934 acres), and contain six seams varying in thickness from

0.55 m. to 1.1 m. (1.8 ft. to 3.6 ft.). The quantity raised during the commercial year 1881-82 was 86,000 tons. The coal is moderately bituminous. The depth of the workings is 300 m. (984 ft.). The winding engine, erected in 1873, has two vertical cylinders 0.60 m. in diameter (23.6 in.), and has valves moved by cams. The pumping engine is direct-acting and condensing, without expansion. The diameter of the steam piston is 1.50 m. (59.1 in.); and that of the pumps is 0.40 m. (15.75 in.). The stroke is 2.17 m. (85.4 in.). There is a dam which keeps back the water at a level of 108 m. below the surface (354 ft.).

*Workmen's Town.*—At Renory, on the borders of the district of Ougrée, the Society possesses a "workmen's town" commenced in 1873. The houses are placed to face E.S.E., which is the most favourable aspect under the prevailing winds, and gives sufficient sunshine. They are grouped two, three, and four together, and arranged to have plenty of light and air. There is as much variety as possible in their appearance. Each is surrounded by a garden, which, on an average, contains 300 sq. metres (3230 sq. ft.). They all have cellars, and are of two types—one of them having two rooms to each floor, and the other only one. One-third of the houses are allowed to take lodgers, and have a special room for the purpose, divided into three compartments by partitions at the height of a man. There is a well for every eight houses, giving an ample water supply. The gardens are divided by fences partly of stone, partly of cast iron, and partly of wood. The rent is 15 francs per month for the larger houses, or 20 francs if there is a lodger's room; and 12 francs for the smaller houses. The taking, giving up, and maintenance of the houses, are under strict rules, a copy of which is fixed in each house.

## DESCRIPTION OF THE OUGRÉE IRON AND STEEL WORKS.

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SUPPLIED BY THE KINDNESS OF THE MANAGING DIRECTOR, M. A. RAZE.

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The manufactures at these works are merchant iron, puddled steel, and fine-grained or Best-Best iron; also girder and boiler plates, axles and tyres for carriages and engines (both in steel, fine-grained iron and puddled steel), steel rails, and every kind of rolled steel, such as bars for railway springs, mining drills, &c.

The works comprise:—

(1) A puddler's shop having fifteen double furnaces, two roughing trains, and three shingling hammers. The production in puddle bar is 75 tons per 24 hours: the pig being the white pig of the Ougrée furnaces.

(2) A Bessemer shop with two 7-ton converters.

(3) A plate-rolling mill with a 5-ton hammer and three heating furnaces.

(4) A merchant mill with three heating furnaces, and a mill for small bars with one furnace.

(5) A tyre mill, with three hammers of 7 tons and one of 15 tons, and with five heating furnaces.

(6) An erecting-shop, a forge for axles, a boiler-shop, and a foundry.

A new rail-mill with three-high rolls is in course of construction.

The Society own five-eighths of the colliery of Six-Bonnières, and take the whole of the output belonging to them for their own consumption.

In 1872 the Society applied the Bicheroux system to its heating furnaces, and in 1876 to its puddling furnaces. For the last two years every furnace in the works has been upon this system. With regard to re-heating, exact figures are impossible, but the advantages

are equal to those in puddling; and the saving is not less than 25 per cent.

The Bicheroux puddling furnace consists of—

(1) A gas generator, receiving only a small quantity of air, so as to produce carbonic oxide.

(2) A mixing chamber, into which this gas is drawn, together with external air, and where its combustion commences.

(3) A furnace where the combustion is completed, and where the puddling goes on.

The dimensions given to these three chambers vary greatly with the composition of the coal, &c., as does also the size of the flues. The air which enters the mixing chamber passes first under the bottom of the furnace and along its walls; this giving the double advantage that these parts are kept cool whilst the air is heated. The gas which escapes from the furnace incompletely burned is used for heating boilers, as in ordinary puddling furnaces. The working is very easy, so that the dimensions of the puddling furnace can be increased, and two working doors are given to each furnace on opposite sides.

The advantages of the system are as follows:—

(1) *Saving of fuel.*—The puddling of ordinary white pig from Ougrée required with the old furnaces 900 to 1000 kgs. of coal per 1000 kgs. of puddled bar; with the new furnace it requires only 600 kgs. Fine-grained iron, which used to require 1300 to 1500 kgs., now requires only 800 kgs. There is the further advantage that large coal is not required; slack screened to  $\frac{3}{4}$  in. diameter acts perfectly well. The coal used contains only 18 to 20 per cent. of gas, and other coals from the same basin have been employed with equal success.

(2) *Saving in yield and improvement in quality.*—The saving in yield is from 3 to 4 per cent.; the loss in puddle bar being only 9 to 10 per cent. on the pig, instead of 13 to 15 per cent. as formerly. At the same time the quality is improved, from the complete exclusion of cold air, which cannot come either through the fire-holes or through the grate, the latter being always covered with a thick layer of coal.

(3) *Saving in repairs.*—The two doors allow easy access to all parts of the floor, which can thus be kept in perfect repair; and as the coal is never in contact with the bridge, the latter lasts much longer, often for several weeks.

(4) *Durability of the fire-bars.*—This is due to the low temperature of the hearth and the quantity of clinkers which can be left upon the grate. Fire-bars about  $1\frac{1}{4}$  in. square are found to have their edges sharp after five months' working.

(5) *Improvement in the condition of the workmen.*—With the same rate per ton, a puddler working at this furnace can earn 25 to 30 per cent. more than at an ordinary furnace.

The first cost is less than that of two ordinary furnaces, the production of which is together scarcely greater than that of one gas furnace. Many parts belonging to the old furnace can be used for the new. The workmen soon become accustomed to the work, and it is never necessary to send special workmen to an establishment on its first adopting the system. The number of master puddlers in the works may be diminished by about one-half, and the number of tools to be kept in order in the same proportion. The first cost is not above 2000 francs per furnace (£80). The steam produced is the same as from two ordinary furnaces, and the gases are completely burned by the time they arrive at the chimney. The bottom of the furnace, the means of cooling the bridges, &c., &c., can be arranged exactly as usual. Finally, the cleaning of the grates is less troublesome than with ordinary furnaces.

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## NOTE ON THE VAL ST. LAMBERT GLASS WORKS.

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(PREPARED UNDER THE SUPERINTENDENCE OF M. JULES DEPREZ,  
MANAGING DIRECTOR.)

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This Society has existed since 1825, its works partly occupying an ancient convent of the same name. It has increased rapidly since 1850, and now has eight shops, with twenty furnaces, and occupying an area of more than 6000 square metres ( $1\frac{1}{2}$  acre). The raw materials are prepared in special rooms at the works. The sand is washed, the potash and saltpetre refined, and the red lead is manufactured. The pots or crucibles required are also made on the spot with the greatest care. The furnaces are rectangular, oval, or circular, and some of them are worked by gas on the Siemens system. Each contains twelve to fourteen crucibles. The waste heat is employed for generating steam in Belleville boilers: the steam being used for working the machines which cut the glass. Formerly the cutters were worked with foot-lathes, with which light work was alone possible. Afterwards a water-wheel was employed, but in 1846 the first steam engine was erected, and within a year the whole of the cutters were supplied with steam power. There are four of these cutting shops, and the total number of lathes is 800.

The engraving on glass still continues to a great extent in its original form, that is to say, by a small wheel worked with the foot. Three systems have been introduced in succession as substitutes. The first works by means of fluoric acid, the pattern being traced in a special ink. In the second system the same acid is employed, but the pattern is cut by the point of a chasing machine in a coating spread over the glass. The third method is the sand blast of Tilghman.

The whole works are lighted by their own gas, and are connected by branch railways with the line from Liège to Namur and with the Meuse. In addition to the glass works proper there are fitting shops, chiefly used for constructing the moulds; also forges, shops

for making packing cases, stores, packing rooms, &c. The total make is about 120,000 articles per day. To pack this quantity there are used each month 50 tons of hay, 55 tons of straw, and 250,000 feet run of boards. The works consume each year 7,000 tons of sand, and 1,500 tons of fire-clay. The total weight delivered from the works is 9,000 tons per annum.

The works possess schools for the children of the workmen, especially a School of Design and a School of Music. They have also 186 workmen's houses, each with a garden, as well as sixteen model dwellings at Ivoz. There is a Savings Bank and Investment Society for the workmen, and also a Sick Fund. The Society has also founded a co-operative store for the workmen, and societies for music, choral singing, gymnastics, &c.

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## NOTES ON THE MANUFACTURES OF VERVIER.

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BY M. ÉDOUARD PELTZER, JUN., OF VERVIER.

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The industrial district of Verviers, one of the most important in Belgium, having a population of 75,000, comprises several communes, of which the chief are Verviers, Dison, Hodimont, Dolhain, Ensival, and Pepinster. The principal industry is the making of woollen yarns and woollen cloth. Other trades which are dependent on this, such as the construction of steam engines and of machinery peculiar to the woollen trade, carding, tanning, &c., complete the facilities offered by the district of Verviers for the working of wool.

The proximity of the coalfields of Liège and Herve ensures a supply of the necessary fuel under favourable conditions. The great reservoir of La Gileppe, formed by the largest dam in the world, furnishes the works with water of perfect purity. The content of this reservoir is 13,000,000 cubic metres. Assuming that it is filled twice in the year, it appears that more than 25,000,000 cubic metres of water are placed annually at the disposal of the trade. Water is supplied to large users at  $1\frac{1}{2}$  centimes per cubic metre, and to others at 5 centimes. In 1882 the town sold 14,000,000 cubic metres of water for trade purposes, and 350,000 cubic metres for domestic purposes.

Its central position, numerous lines of railways, and proximity to the port of Antwerp, place the district in communication with every part of the globe, both as regards the supply of raw material and the delivery of manufactured products. The following figures will give an idea of the commercial movement in the district.

The importation of raw wool is on an average 150,000 bales per annum, weighing about 48,000,000 kilogrammes. They come from Buenos Ayres, Monte Video, Sydney, Melbourne, the Cape, &c.

The exportation is about 9000 bales per annum, weighing about 2,000,000 kilogrammes. Hence there remain about 46,000,000 kilog. which are worked up in the district, and which represent about 16,000,000 kilog. of washed wool. To these have to be added the washed wool imported (skin wool from the south of France, &c.), which is about 2,000,000 kilog. There is thus a total of 18,000,000 kilog. of washed wool to account for. Of this, 11,000,000 are exported to Germany, Russia, Holland, Austria, &c.; and 7,000,000, together with 3,000,000 to 4,000,000 kilog. of secondary products, such as noils, waste, &c., are used up in the spinning mills. The woollen yarn exported is to the amount of 8,000,000 kilog., and the cloth 2,500,000 kilog. The markets for yarns do not extend beyond Europe, and are chiefly in England, Scotland, and Germany; but the cloth is sent throughout the world, and includes every quality from the finest to the most common.

### WOOL-WASHING WORKS OF M. EUGÈNE MÉLEN.

A. *Washing*.—The processes here are as follows:—

(1) *Sorting (Triage)*, or separation of the fleece into different divisions according to the quality of the wool as to fineness, length, &c.

(2) *Washing (Lavage)*, which takes place in hot baths, made alkaline by soda, and is done by the washing machine called the “Leviathan.” The wool is passed through these baths successively by self-acting machinery.

(3) *Drying (Essorage)* by the hydro-extractor.

(4) *Final drying by hot air (Séchage)*, the wool being stationary or having merely a motion of translation. The drying in the latter case is of a more regular character.

(5) *Mechanical cleaning (Échardonnage)* by a cleaning machine. It is this process that has brought the Buenos Ayres wool into such extensive use.

B. *Chemical Cleaning*.—Generally applied to the waste products of the wool, and sometimes to the wool itself. The object here is to separate from the woollen fibre all the vegetable substances, such as

seeds, thistles, &c., which cannot be separated by mechanical means. The operations are :—

- (1) Dipping in acid baths (*Trempage*) with subsequent drying.
- (2) Charring (*Carbonisage*), the wool being exposed to a strong heat in a furnace, whereby the thistles, &c., become black and friable.
- (3) Beating (*Battage*), to knock out the impurities, and leave a material ready for spinning, which, if not equal to the wool itself, is still an excellent raw material, formerly lost. The machine here used is an invention of the late M. Mélen.
- (4) Placing in alkaline baths (*Désacidage*), to remove the last traces of acid ; and drying by hot air.

The motive power used in the works consists of a multi-tubular boiler on the Pétry-Chaudoir system, and a twin steam-engine on the Gorissen system.

## LA VESDRE WOOL-COMBING AND SPINNING WORKS.

(Managing Director : M. MATH. DRÈZE-RICK.)

A. *Combing*.—The operations here are as follows :—

(1) Sorting; washing by soap in a washing machine constructed by the Société de Constructions Mécaniques of Verviers; partial drying on the Méhl drum, and automatic oiling (*Ensimage*).

(2) Carding (*Cardage*). The object here is simply to lay the fibres roughly parallel to each other. The wool when carded is brought into slivers by passing it through a funnel.

(3) Drawing before combing (*Étirage avant Peignage*). The machines for this purpose unite several of the slivers into a single sliver of the same diameter, by forcing them between the teeth of a cylinder furnished with combs, called “*hérissos*” (porcupines). The fibres are thus drawn out and laid sufficiently parallel for combing.

(4) Combing (*Peignage*). This is the most important process. The combing machines separate the long from the short fibres, and also comb out all the impurities, such as buttons, burrs, &c. The long fibres form the top, the short fibres the noils. Heilmann was

the inventor of the ingenious mechanism which forms the basis of the combing machines of Schlumberger, Meunier, Barbier, &c., which are chiefly employed at Verviers.

(5) The slivers which leave the combing machine have very little strength. The doubling machine (*Vide-pots*) doubles these on each other, and gives them greater solidity by means of friction and drawing.

(6) The drawing before backwashing (*Étirage avant Lissage*) completes the work of the doubling machine.

(7) Backwashing (*Lissage*) cleans the wool of grease, &c., and smoothes the slivers, laying every fibre flat so as to give a more brilliant appearance to the wool, which is now ready for spinning. The process consists in passing the slivers first through baths of soap and water and then over cylinders heated by steam, and made by Skene and Devallée, of Roubaix.

B. *Spinning*.—The processes are the following:—

(1) Preparation. The combed sliver is equalised and thinned down by passing it successively through roving frames analogous to those employed in combing.

(2) Spinning (*Filature*). Here self-acting mules are alone employed. They draw out the sliver to any required thickness, giving it at the same time the twist which is necessary for its strength.

(3) Folding (*Retordage*), or joining two or more threads into a single one, in order to obtain a yarn of greater strength. Colouring effects are often produced by folding threads of different shades.

Dyeing may be carried out on the sliver or on the yarn. Generally the former method is employed. The combed sliver after smoothing is divided into skeins, which are hung upon bars above the dyeing vats.

The motive power is given by means of boilers having 280 square metres of heating surface, and built by Mathot and Bailly, of Chênée. There is a condensing steam engine of 250 HP., built by the Société de Constructions Mécaniques on the Bède and Farcot system, and having variable expansion worked by the governor.

## SPINNING WORKS FOR CARDED WOOL, OF M. HAUZEUR-GÉRARD FILS.

The processes here are as follows:—

(1) Greasing or oiling (*Ensimage*), generally by oleine.

(2) Carding (*Cardage*). Here there are three machines: the Breaker or Scribbler (*Ploqueteuse*), the Clearer (*Repasseuse*), and the Condenser (*Continue*). The two first open the fibres of the wool, forming it into a film, called first or second “mapping;” whilst the third divides this film and transforms it by rubbing into rovings.

(3) Spinning. This is done by self-acting mules, generally of English make, either by Messrs. Platt Brothers or Messrs. Parr Curtis and Co.; or else by the frame spinning machines of Célestin Martin of Verviers. In the first system the drawing and twisting of the yarn are produced by the advance of the carriage and the rotary motion of the spindles. In the second the two operations are done separately, but one immediately after the other.

(4) Folding, as above described. This is done by special machines, built by Sykes, Hetherington, &c.

(5) The yarn must be reeled. The machines for this purpose (*Dévidage*) are provided with an arrangement which stops the whole machine if a single thread breaks (Snoeck's system).

The motive power is given by tubular boilers with two heating-tubes, and by a steam engine built by Nollel, of Ghent.

## MANUFACTURE OF CLOTH, SATIN, WORSTED, AND WOOLLEN GOODS, BY MESSRS. PELTZER ET FILS.

In these works, which employ 1700 workmen, the whole of the operations above described are in use, the wool coming into them in the fleece, and going out as cloth, &c. But only the processes for “Weaving and Finishing” are here dealt with. These processes are as follows:—

(1) Warping (*Ourdissage*), the object of which is to lay the threads in the proper order.

(2) Dressing or Sizing (*Encollage*): passing the threads through

a bath of size, to give them more strength when undergoing the severe treatment of the loom.

(3) Weaving (*Tissage*). The tissue is formed by the crossing of two series of threads lying at right angles to each other. That which is lengthwise to the piece is the warp, the other is the weft. The loom locks these two together at each "shoot of the weft;" the warp is separated into two portions, one half moving upwards and the other downwards, and these hold the weft between them. The looms are made in England, Germany, or Belgium.

(4) Milling and washing (*Foulage et Lavage*). These operations are with the object of tightening the tissue, so as to give it more strength, whilst at the same time preserving its suppleness and elasticity.\* They also serve to clean the piece from the oil which is still contained in it, and which has been imparted to the wool before spinning.

(5) Teasing (*Garnissage* or *Lainage*). Milling forms upon the piece a sort of down, consisting of filaments standing up irregularly from the surface. These must be drawn up and ranged parallel to each other. This is accomplished by a machine carrying frames which are set with teasles.

(6) Tentering (*Ramage*), which is done either on tenter frames or in special machines.

(7) Shearing (*Tondage*), which gives a uniform length and appearance to the filaments.

(8) Pressing (*Pressage*), which consists in exposing the cloth to the simultaneous action of a high temperature and a considerable pressure, under hydraulic presses or rolls. It is this operation which gives the brilliance to the cloth.

(9) Steaming (*Décatisage*), which is simply to fix the lustre by means of steam at low pressure passing over the pieces of cloth, which are rolled on perforated copper cylinders.

The motive power is given by tubular boilers on the Fairbairn system, and by two vertical engines, one high-pressure, and the other low-pressure receiving the exhaust steam of the first.

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\* They are carried on in a separate establishment at Renoupré, to the east of the town.

**WOOL-CARD MANUFACTORY OF M. DUESBERG-DELREZ.**

The processes here are :—

- (1) Cutting and preparation of the leather.
- (2) Setting of the points of the cards upon ribbons or strips of leather ; or in other cases of leather and felt, of cloth and felt, or of cloth only. This is done by very ingenious machinery.
- (3) Sharpening and finishing the points of the cards with emery polishers.

The motive power is given by a boiler with two heating-tubes, and by an engine with variable expansion worked from the governor, and built by the Société de Constructions Mécaniques of Verviers.

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## LA GILEPPE RESERVOIR DAM.

[The following notice is abstracted from a paper by MM. M. Bodson, E. Detienne, and F. Leclercq, prepared for the Association of Engineers from the University of Liège.]

The construction of the reservoir at La Gileppe, which is closed by the largest masonry dam in the world, was rendered necessary by the large demand for water in the town of Verviers, not only for drinking purposes but for the washing of wool &c. in the large cloth manufactories of the town. In 1857 the question of waterworks for Verviers was put into the hands of M. Bidaut. It was decided that the requirements should be placed at 40,000 cubic metres per day (8,800,000 gallons), and that the water must be very pure, specially as regards lime. The Gileppe river entering the Vesdre a few miles above Verviers (see district map, Plate 29), satisfied all the conditions and was chosen accordingly. After a careful examination a finished design was presented in 1868. In April 1869 the works of the dam were commenced, and they were completed on the 1st November 1875. In order to give sufficient storage capacity it was necessary to have a dam with a height of no less than 45 metres (148 ft.); which was not however without precedent, as the dam at Furens, then under construction, has a height of 51 metres (167 ft.). The actual height of the parapet at La Gileppe is 2 metres more, or 47 metres (154 ft.); but the by-wash at each side keeps the reservoir at the normal level of 45 metres above the base. The water is taken from the reservoir by two subterranean galleries C C, Fig. 1, Plate 53, each in connection with a shaft D, through which the valves are manipulated. During the construction these galleries were utilised for carrying off the water of the river. They are lined throughout their length, the sides being in masonry and the arch in brickwork. Their construction was the first work undertaken, and was completed in May, 1869. They gave valuable

information as to the nature of the rock, which was found to lie regularly in almost vertical beds, and to yield very little water.

In the construction of the dam itself it was specially necessary that it should be solidly united with the rock at each end, and also that there should be the closest possible junction between the base of the masonry and the ground beneath it, to prevent all chance of leakage. The first thing was to settle the ground plan and section of the dam. The former was made in the shape of a curve, concave to the reservoir, probably with the view that something of the advantage of an arch would thereby be obtained. The radius of the curve was 500 metres (550 yards). With regard to the section, the engineer was chiefly guided by the two great dams of Alicante and Furens (Saint-Étienne), shown in Figs. 3 and 4, Plate 53; but it is made wider than either of these both at top and at bottom. The actual section is shown in Fig. 2. His reason for these ample dimensions was probably that the quantity of water in the reservoir was much larger than in the other cases, and also that the dam itself was much longer. The form of the slope in the rear was so arranged as to give the utmost strength both against the overturning of the dam and against sliding at the base. The latter was also prevented by the stepping of the masonry into the rock, Fig. 2, which offered every guarantee against leakage. The masonry was entirely of limestone, chiefly brought from Béthane on the right bank of the Vesdre, opposite to the Gileppe valley. Part of the masonry on the inside was of stone obtained on the spot. It was not laid in regular courses, but with a very large number of headers amongst the stretchers, so as to unite the whole mass firmly together. The dressed stones for the faces were laid exactly tangential to the curve; behind these were placed rough hewn stones laid at right angles to the curve, and the interior was then filled in with rubble. Before laying a fresh course the upper surface was carefully cleaned, and covered with a layer of mortar sufficiently liquid to run into the holes, &c. This mortar was composed of five parts of lime, four parts of sand, and one of trass. The by-washes B B, Fig. 1, are in the form of steep channels cut in the solid rock. At the upper end the width is 25 metres (82 ft.), which is amply sufficient for the

discharge of the water, even in the highest floods. The slope from thence downwards varies from 1 in 10 to 1 in  $2\frac{1}{2}$ . Above them the earth is dressed back to a slope of 1 in 4.

The water is taken off from the reservoir through the two galleries already described, which lie in the shape of a horse-shoe round the dam, as seen in Fig. 1. At the entrance end of each is a grating A for the purpose of filtration. Passing through this the water flows through the gallery till it reaches the sluices O. Here the gallery is closed by a mass of masonry, through which are laid two cast-iron pipes of 0·85 metre diameter (34 in.). Through these the water passes into the working chamber. Each pipe is closed at the lower end by a self-acting valve, beyond which is another pipe of the same diameter leading to a double-beat valve placed in the shaft D, and worked by gearing from this shaft. After passing this chamber the water arrives at another dam of masonry P, also provided with double-beat valves. Immediately below this is the safety-sluice V. From this point the two pipes continue of the same diameter as before to the outer end of the gallery. Gradually turning towards each other, the two galleries are united at F, where there is a junction valve. A little on one side of this valve two pipes K lead off from the pipes coming from the left bank, and conduct the water to a well I, from whence starts the aqueduct leading to Verviers. Before entering the aqueduct the water passes through a measuring apparatus. A set of sluices at F enable water to be discharged from the reservoir into the old bed of the river, so as to maintain a better level in the Vesdre in time of drought.

The dimensions &c. of the dam are given below.

Total height . . . .	47 metres.	154 feet.
Height to level of water .	45 „	148 „
Length at base . . . .	82 „	269 „
Length at coping . . . .	235 „	771 „
Thickness at bottom . .	65·82 „	216 „
Thickness at coping . .	15 „	49 „
Total content of masonry .	248,470 m. cb.	8,774,870 cb. ft.
Weight . . . . .	574,481,000 kg.	571,481 tons.
Section at greatest height	1720 sq. m.	18,510 sq. ft.
Area of reservoir . . . .	80·05 hectares.	197·8 acres.
Content of reservoir . . .	12,238,916 m. cb.	432,224,663 cb. ft.

The centre of the coping is occupied by a lion in sandstone, resting on a granite base, 8 metres high ( $26\frac{1}{4}$  ft.). It was carved by M. Félix Bouré out of 203 different blocks of stone, of which the smallest contained 1·5 c. metres (53 c. ft.). The total content of the statue is 350 c. metres (12,360 c. ft.), and its weight 300,000 kg. (300 tons).

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## NOTES ON THE TRADE OF ANTWERP.

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(PREPARED UNDER THE SUPERINTENDENCE OF M. G. A. ROYERS, OF ANTWERP.)

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The commercial greatness of Antwerp dates from the fifteenth century, and culminated during the first year of the reign of Philip II. At this time the population was about 200,000, and as many as 2500 ships might be seen lying in the Scheldt at one time. A single tide would sometimes bring 400 vessels into the port, and each week there arrived about 1000 wagons loaded with merchandise from Germany, the Hanseatic towns, Lorraine, and France; as well as 10,000 country carts bringing provisions, &c. In the wars of the Reformation however Antwerp suffered more than any other town, and was completely ruined. In 1589 the population was only 55,000, and during the seventeenth century it fell to 40,000.

It was not until the Treaty of The Hague, in 1795, made navigation free on the Scheldt that the city began to recover from its long decline; and it was the period of the Consulate and Empire which established the regeneration of the port. Antwerp then became a great maritime arsenal and dockyard, in which was to be constructed the fleet destined for the invasion of England. The fall of Napoleon put a stop to these vast undertakings; and between 1815 and 1820 the docks and quays were handed over by the Government to the town, and became its sole property. The expenses thereby incurred were met by the establishment of port dues. From that time the development of the port has been rapid and immense.

*Docks.*—The new docks, &c., which this development has necessitated, are described in the special paper by M. Royers (*ante*, p. 494). A few words may however be devoted to the commercial progress of the town. The following Table A gives the tonnage

arriving at the port in successive years, and also the traffic in the goods stations.

TABLE A.

Year.	Vessels Arriving.		Traffic in Goods Stations.		
	No.	Tonnage.	Departure.	Arrival.	Total.
		Tonnes.	Tonnes.	Tonnes.	Tonnes.
1870	4122	1,386,833	616,470	351,604	968,074
1871	5164	1,824,115	818,009	365,056	1,183,065
1872	4193	1,641,653	769,951	444,729	1,214,680
1873	4797	2,062,236	910,641	383,214	1,293,855
1874	4547	2,134,162	945,573	599,035	1,544,608
1875	4351	2,185,416	902,192	746,656	1,648,848
1876	4550	2,527,679	1,112,079	726,173	1,838,252
1877	4457	2,499,482	1,072,137	865,109	1,937,246
1878	4583	2,779,956	1,208,994	827,796	2,036,790

It will be seen that both the tonnage and traffic doubled themselves in the interval between 1870 and 1878. During the same period the estimated amount of money passing in commercial transactions rose from 1,742,000,000 fr. in 1870 to 2,807,000,000 fr. in 1877; and this in spite of the commercial crisis which occurred in the interval.

In addition to the ocean trade, there is a very large trade carried on by barges through the various canals which have their outlet at Antwerp. In 1878 the total of this trade was represented by 32,181 barges, with a gross tonnage of 1,512,039 tonnes.

It may be interesting to compare the traffic of Antwerp with other ports. For this purpose the following Table B will be sufficient, although it is possible that the figures given may not represent quite the same elements for the different ports.

Whilst the position of Antwerp as regards trade is thus shown to be second to none on the Continent, the accommodation for it remains

TABLE B.

No.	Ports.	No. of Vessels.	Tonnage.	Mean tonnage per vessel.
			Tons.	Tons.
1	Antwerp . .	4550	2,221,000	546
2	London . .	11601	5,200,000	447
3	Liverpool . .	5381	4,332,000	821
4	Hamburg . .	5260	2,182,000	399
5	{Newcastle and Shields . }	6537	2,176,000	328
6	Marseilles .	5345	2,044,000	382
7	Hull . . .	3469	1,512,000	436
8	Hâvre . . .	2922	1,482,000	532
9	Rotterdam .	3443	1,383,000	401
10	Cardiff . .	3047	1,146,000	376
11	Southampton .	1830	744,000	406
12	Bordeaux . .	1677	719,000	428
13	Bremen . .	2046	612,000	299
14	Dunkirk . .	2206	592,000	269
15	Glasgow . .	825	547,000	662
16	Boulogne . .	1775	398,000	224
17	Amsterdam .	1171	386,000	329

very insufficient. In 1876 the relation of the tonnage to the length of quay was 300 tonnes per metre (say 270 tons per yard), which is about four times as great as it is at Liverpool. Despite the use of hydraulic cranes, and of special appliances for towage in the basins, for loading of grain, &c., the block in the traffic is great, and not merely are the present extensions urgently required, but still further increase will probably be demanded ere long.

*Stations.*—Until recently the only railway station in Antwerp was the Eastern or Borgerhout Station, together with some goods sheds on the north and east of the great docks. In 1871 a contract was made with the government for a large extension of railways, which is now completed. The Eastern Station is now reserved entirely for

passenger traffic, and for what may be termed express goods traffic, such as the carrying of cattle, parcels, &c. It contains two running sheds, one for the Grand Central, and the other for the State Railways of Belgium. In the Eastern Station are pumps lifting the water of the Herenthals Canal to a large tank, which also supplies the station at the docks, the water found at the latter being of too hard a character.

At the docks are two separate depots. The first, called the Stuyvenberg Station, is exclusively for goods traffic, and also contains a repairing shop for locomotives, lighted by Siemens electric lamps. At this station the goods trains are made up, and all the slow-speed traffic arranged. Immediately beyond it is the principal dock station (Station Principale), which serves for the classification and marshalling of wagons on their arrival, and the arranging of wagons which are going to or coming from the sidings on the quays. Goods landed or embarked at quays not furnished with sidings are also loaded or unloaded in the station. This takes place in a shed 200 metres by 70 metres (655 ft. by 230 ft.), but traversed by two roads 12 metres wide (40 ft.). Beside these roads are platforms 8 ft. wide, and beyond these are railway sidings. On the platforms are 28 hydraulic cranes of 1 to 2 tons, and in the sidings are 12 capstans and 12 pulleys for hauling the wagons. In this shed 350 wagons can be easily loaded per day. In the open yard are 12 capstans with 26 pulleys, nine 1-ton or 2-ton cranes, four 5-ton cranes, and one 10-ton crane. Within this station is also comprised a repairing shop for wagons, with an area of 1200 sq. metres (12,900 sq. ft.), and capable of accommodating 200 wagons.

The station is furnished with hydraulic machinery upon the system of Sir William Armstrong & Co. The main engine-house has an accumulator weighing 100 tons, worked by a pair of engines in the ordinary manner, and compressing the water to a pressure of 50 atmospheres. From hence the pressure water is conveyed in pipes to the points where it is required. To avoid frost the pipes are buried at a depth of 1.5 metre (5 ft.), and in addition there are at certain points burners, supplied with a mixture of coal gas and air. This water works the hauling capstans within the station, and also

the hydraulic cranes, both those under the station roof and those in the open air.

The Station Aux Bois, close to the dock of the same name, is mainly used for the timber trade.

The total area of these dock stations and their sidings is 50 hectares (123 acres); and they have above 40 kilometres (25 miles) of sidings, capable of taking 6000 wagons. In 1878 the weight of goods forwarded was 1,208,994 tonnes, and of goods received 827,790 tonnes. The number of wagons received was 283,881, and forwarded 285,557. Taking the whole of the stations together, 2366 wagons were handled every 24 hours.

The Southern Station was decided upon in 1874; it occupies an area of 800 metres by 260 metres (2600 ft. by 850 ft.). It is especially intended for the service of the new quay along the Scheldt. The connecting lines divide as they leave the station, and pass respectively over the upper and lower lock of the entrance to the docks for small craft. By this means the traffic will not be interrupted by the opening of the swing-bridge over one or other of these locks. The station will probably be connected with the other side of the Scheldt by a bridge carrying two lines of railway. It is already connected with the main network of railways by a new line passing by Hoboken. It will be brought into direct communication with the Northern Railway of France by a line from Antwerp to Douay, now under construction.

Lastly, the Pays de Waes Station has been placed upon the new quay, and serves as a depot for the railway of the same name, which has its present terminus at the other side of the Scheldt.

*Diamond Works.*—One of the most remarkable of the industries carried on at Antwerp is the cutting of diamonds. About 300 years ago an Antwerp lapidary discovered the art of cutting the diamond by means of its own dust. Continuing his efforts he soon discovered various ways of arranging the facets so as to reflect the rays of light, and give the well-known diamond lustre. This workman, whose name was Berchem, left numerous pupils, who followed the trade and transmitted the secret to their descendants. Since then diamond-cutting has always existed at Antwerp, though it has passed through

various phases, and at times has almost been extinguished for want of raw material, or from political or financial difficulties. A little before 1869 it seemed to have received its last blow; but shortly afterwards an unexpected discovery restored it to vigour and prosperity. In 1876 the first diamonds arrived from the Cape of Good Hope, and were soon followed by so many others that the workmen who had given up the diamond-cutting trade returned to it with new ardour; the diamonds supplied by the Kimberley mines being sufficient for the whole of their demand. In a short time the number of workmen was doubled or trebled, and they now number from 2000 to 2500. Their wages are extremely high: some of them get 1000 francs per week (£40), or more, and the very poorest receive about 50 francs (£2) per week. This lowest figure would give for 2000 workmen a total weekly wage of £4000; and this total, though a considerable one, is much below the reality. The firm of Kryn-Huybrechts et Fils (to whom this information is due, and who kindly invited the members to visit their works) pay £600 to £800 weekly to the 150 workmen they employ.

A great advantage to the trade has been the application of steam. Previously manual labour was almost exclusively employed in turning the steel plates required to polish the diamonds. This occasioned a great loss both of money and time, the power available being often insufficient for large brilliants.

Since 1870 the progress of the trade has been rapid and without any interruption. It is often alleged that the Cape diamonds cannot be compared with those of India, but those now being cut are in reality far superior to the older diamonds; and the African mines have furnished gems which, in purity, brilliance, and water, are quite equal to the best diamonds of ancient times. Most of the diamonds are imported through London.

M. Coettermans, who also invited the members to visit his works, has kindly supplied some further information. He employs about 100 workmen, and has eighty grindstones cutting brilliants, roses, and other forms of diamond. They supply the cut diamonds to all parts of the world, including India, for which country the diamonds have to be cut very thick, and placed the reverse way to the ordinary setting, or upside down. The diamonds are cut by

means of a cast-steel horizontal revolving disc, on which is thrown a mixture of fine diamond-dust and oil. The diamond is partly embedded in a mass of lead, fastened to the end of a short bar, and the face standing out is pressed down upon the revolving plate, and slowly ground to a flat surface. No templates are used, and the form given to the stone is wholly due to the correctness of the workman's eye.

Amongst other trades which exist at Antwerp, or in the neighbourhood, may be mentioned the following :—

(1) Brick and tile works, chiefly at Boom and in the neighbourhood. This trade dates back to the fifteenth century, and now employs about 10,000 workmen. The annual output is from 800 to 900 millions of bricks, besides tiles, &c.

(2) The copper works at Hemixem, making copper from pyrites found in the island of Karmö in the south-east of Norway.

(3) The shipyard of the Cockerill Society at Hoboken.

(4) The manure works of Messrs. Ohlendorff at Burght, making what is known as "dissolved guano of Peru."

(5) The Royal Stearine Candle Works at Borgerhout. These works were founded in 1850, and now supply 50,000 packets of candles per day.

(6) Rice mills, of which there are six, making 40 to 50 million kgs. per year.

(7) Distilleries, which are on a large scale, making about 60,000 litres (13,200 gallons) per day.

(8) Sugar refineries, of which there are three, making 10 to 12 million kgs. per year. There are in addition twenty refineries for sugar candy.

(9) Tobacco works, which are considerable, there being about twenty-six works for the manufacture of cigars alone. About 80 million cigars are produced per annum.

(10) Wool-combing works at Merxem, chiefly for the fine wool of South America and Australia.

(11) Sulphur refineries, varnish works, silk works, oil works, &c.

## DESCRIPTION OF WORKS, &c., VISITED AT GHENT.

BY M. GALLAND, INGÉNIEUR PROVINCIAL.

### FERDINAND LOUSBERGS SOCIETY'S COTTON MILLS.

*Managing Director, M. Joseph de Hemptinne.*

This important establishment is situated in the centre of the town, and was founded in 1823 by M. Ferdinand Lousbergs, who died in 1859. It was left by him to the children of his sister, Madame de Hemptinne, and was formed by them into a company. The works cover an area of 4 to 5 hectares (10 to 12½ acres), and employ 1800 hands. The motive power is produced—

(1) By a Woolf compound engine with variable expansion and of 1000 HP.

(2) By another pair of engines of the same type of 500 HP.

(3) By a simple engine with variable expansion, of 300 HP.

There is thus a total power of 1800 HP. These engines were all built by MM. Gilain, of Tirlemont, and are fed by fourteen tubular boilers with heaters, working at 4½ atmospheres pressure. The motion is carried to the top of the mill by vertical shafts, each weighing, with their fittings, about 25 tons, and by bevel gear.

These engines together work 70,000 spindles and 1400 looms. The production includes all kinds of cotton goods, such as damask, piqué, satin, counterpanes, &c. The out-put is 33 tons of thread, and 2300 pieces of cotton per week. Among the machines are some built by Platt Bros., of Oldham; Hetherington & Sons, of Manchester; John Dugdale (late Harrison & Sons), of Blackburn; William Smith Bros., of Heywood; Howard & Bullock, of Accrington; and the Phoenix Société, of Ghent, Manager M. Vermandel.

A special point to be noted is the mode of lubrication of the lower end of the upright shafts, and of the foot-step. Formerly

these were lubricated by oil ; but great inconvenience resulted from this, and despite the closest watching the oil was occasionally found deficient. In consequence, the friction of the shaft produced heating of the surfaces nearly up to the melting point. The lubricant is now water, according to a happy invention of the Managing Director, M. Joseph de Hemptinne, and all difficulty has disappeared. The process is based upon the principle of the hydraulic press, and consists in raising the upright shaft through a very small distance by the pressure of the water admitted below it ; a film of water is thus introduced between the shaft and the pivot. This water is conducted from four bucket and plunger pumps through a pipe of 0.01 m. in diameter (0.4 in.). This pipe is introduced through the footstep, and terminates in an opening 0.1 m. in diameter (4 in.) immediately under the lower end of the shaft, the water pressure being 320 kgs. per square centimetre, or 4500 lbs. per sq. in. The lubrication is continuous, and the water which escapes is collected in a tank, which surrounds the foot-step.

#### FLAX AND TOW MILLS OF THE LIÈVE SOCIETY.

*Managing Director, M. Louis Desmet.*

These works occupy 5 hectares ( $12\frac{1}{2}$  acres) of ground, and employ 1300 men. The motive power is produced by a Corliss beam-engine with one cylinder and with variable expansion. It is of 1200 HP., and was built by M. Van den Kerchove, of Ghent. It works at 4 atmospheres pressure, and actuates 28,000 spindles. It is fed by five boilers, having two heating tubes at the bottom. There are six other boilers, three being in duplicate, for spinning and drying. The motion is transmitted direct by belt and pulley. The output is 15,000 bundles of yarn per week. The machines are built by Messrs. Fairbairn Kennedy & Naylor, of Leeds.

#### COTTON SPINNING WORKS OF M. JULES DE HEMPTINNE.

These works employ 450 men. The motive power is produced by a horizontal engine, with expansion gear on the system of Nolet, of Ghent. It is of 1000 HP., and the pressure is from 4 to  $4\frac{1}{2}$

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atmospheres. It is fed by three boilers with heating tubes, and one multitubular boiler on the Barbe system. The motion is transmitted by belt and pulley. The spinning mills can produce 66,000 lbs. per week of No. 8 to 10 cotton, and the twist mills 10,000 lbs. A small machine-shop is annexed to the works, where are made cards, drawing frames, bobbin frames, &c. Among the machines are some constructed by Platt Bros., of Oldham; Curtis & Sons, of Manchester; and Lord Bros., of Todmorden. Others are the invention of M. Jules de Hemptinne, the proprietor of the works.

#### NEW DOCK WORKS AT GHENT.

These works are at present going on under the direction of M. Vanderlinden, Ingénieur des Ponts et Chaussées, at Ghent, who was the originator of the project. The contractors are MM. Willems and Caze. A length of quay-wall of about 750 m. (820 yards) has already been raised to about 1 m. ( $3\frac{1}{4}$  feet) above the level of the canal. Six caissons still remain to be sunk.

The outer basin, in course of construction, will connect the Ghent docks with the Ghent-Terneuzen Canal. This basin will have an area of 25 acres, and a minimum depth of 21.3 feet; and two graving-docks will open into it, having lengths of 426 feet and 230 feet respectively. The works comprise the excavation of the outer basin for a length of 1200 yards; the construction of a quay-wall on the right bank of the canal, 3400 feet long, and resting on a foundation whose top is  $24\frac{1}{2}$  feet below the water-level of the canal; the erection of 1894 feet of retaining-wall on the two banks; and the formation of a culvert.

The depth to which the foundations of the quay-wall of the basin had to be carried (33 feet below water-level) and the sort of quicksand in which they had to be excavated, led to the adoption of the compressed-air system, similar to that employed at the Antwerp quays. In the first instance, the excavation for the foundations was accomplished for a considerable depth by dredging, the dredged material being conveyed away by means of a pump and floating tubes. As soon as the dredging has been carried to the

desired depth along the site of the quay-wall, the working-chamber caisson, surmounted by removable plate-iron walls serving as a cofferdam, is floated into place between barges carrying a staging, from which it is suspended by chains. The wall is built on the top of the working chamber, within the iron cofferdam, till its weight causes the caisson to rest firmly on the excavated bottom. Compressed air is then introduced into the working chamber, and the workmen descend, through a plate-iron tube resting on the roof of the caisson, and complete the excavation for the foundations. The excavated material is thrown into a box, into which a lift and force pump injects water; and by turning a stop-cock, the mixture of silt and water is driven out by the pressure of air in the chamber through a pipe communicating with the outside. The working chamber is finally filled with concrete through vertical tubes; and as soon as the wall, which has in the meantime been gradually built up, is higher than the water, the iron sides are removed and used for another caisson, and the wall is then raised to its full height. The interval left between each successive caisson is 2 ft. 7½ in., which is filled up with concrete below, and with brickwork above. To ensure the connection of the separate lengths of wall, grooves (1½ ft. by 1½ ft.) are formed in the end faces of each length. The contractors have since found it expedient to do less dredging, so as to make the caisson rest on the bottom in a smaller depth of water, which enables them to commence the wall directly on the top of the caisson without the use of the plate-iron sides; moreover the long and difficult operations with the floating stage are dispensed with, and, though the excavation inside the working chamber is increased, there is no danger of dredging to too great a depth.

#### NURSERY GARDENS OF M. LOUIS VAN HOUTTE.

These gardens, which have been in existence about fifty years, are celebrated throughout the world for their beauty and the care with which they are kept. They occupy 30 hectares (74 acres) and contain fifty conservatories. Plants, shrubs, and trees of all kinds are cultivated, belonging alike to the tropical, temperate, and

arctic zones. The arrangements for watering and heating are of the most complete character. Two sets of water pipes are carried throughout the whole gardens. The first is for watering the plants, and consists of earthenware pipes, which connect 140 wells in cement, scattered throughout the area, and each containing  $1\frac{1}{2}$  c. m. (53 cubic feet). These are supplied from a basin, which is itself fed from a tank containing 64 c. m. (2260 cub. ft.). A 4-HP. engine works two double-acting suction and force pumps, which take water from the Scheldt at 700 metres distance (770 yards), and pump it into the tank, which is placed on the top of the engine-house, 5 m. ( $16\frac{1}{2}$  ft.) from the ground. The second set of pipes is for warming the conservatories. The mains are of cast iron, 0.15 m. in diameter (6 in.), while the branches which traverse the conservatories are 0.09 m. ( $3\frac{1}{2}$  in.). The total length of these pipes is 9000 m. ( $5\frac{1}{2}$  miles), and the temperature of the water varies from  $60^{\circ}$  to  $80^{\circ}$  C. ( $140^{\circ}$  to  $176^{\circ}$  F.). It is heated in sixteen boilers with return flues. The number of pipes in each conservatory varies from four to twelve, according to the temperature desired. The number of workmen employed is about two hundred; in addition to whom travellers are always visiting different quarters of the globe, to search for new plants. The firm publish a magnificent work on the hothouse and garden Flora of Europe, of which 23 vols. have already appeared. A number of artists and engravers are always employed in copying new plants and flowers produced in the gardens.

#### ENGINE WORKS OF MM. CARELS FRÈRES.

These works, founded in 1839, are situated by the side of the docks, and connected with the State Railways at the goods station of Ghent. They cover an area of 11,000 sq. m. ( $2\frac{3}{4}$  acres), and employ 400 men. The motive power for the whole works is produced by an engine on the Sulzer system, of 100 HP. The valves are in equilibrium, and the expansion is varied by the governor. There is besides, in the erecting shop, a horizontal engine of 25 HP., also with expansion varied by the governor. This engine is kept in reserve to work the large planing, drilling, and mortising machines

when required. There are also three Brotherhood engines, to work different tools at times when the main engine is stopped. Steam is raised in a boiler with two internal flues and with Galloway tubes, and also in a vertical boiler heated by the waste heat from the heating furnaces. The erecting shop, foundry, and forge are lighted by sixteen Jablockhoff lamps, worked by a Gramme dynamo-electric machine and by an exciting machine, having together a power of 17 HP. In the shops are a 1-ton and a  $\frac{1}{2}$ -ton steam-hammer, and a spring-hammer worked by belt and pulley. The smiths' hearths are blown by a fan by MM. Sulzer Bros., of Winterthur, Switzerland. The foundry has two cupolas, blown by a fan on the same system, which are capable of running castings of considerable size. The small castings, and the articles in copper for the locomotive engines, are moulded by the Sebold and Neff moulding machine, and there is also a machine for sand-moulding by the same makers. The tools in the fitting shop are by Belgian, English, and German makers. Among others may be noticed a large double planing machine on the duplex system, planing four faces, and capable of planing 7 m.  $\times$  2 m.  $\times$  2 m. (23 ft.  $\times$  6 $\frac{1}{2}$  ft.  $\times$  6 $\frac{1}{2}$  ft.). There is also a large double boring machine on the Daverio system; and a double slotting and drilling machine, chiefly used for shaping locomotive-engine frames, and built by Collier and Co., of Salford, Manchester. There is also a double mortising and drilling machine, principally used for cutting the frames of locomotives, and a large boring machine for boring the frames of Sulzer engines. There is a 5-ton radial crane and also a 10-ton travelling crane in the erecting shop. In the locomotive shop there is a 20-ton travelling crane, and in the foundry a 12-ton radial crane, and a 10-ton travelling crane.

The firm builds horizontal steam engines, especially engines on the Sulzer system with equilibrium valves, and also railway and tramway locomotives. The output yearly is about 20 Sulzer engines, and 40 to 50 locomotives. The boilers come from the Société de Chaudronnerie et Fonderie Liégeoises, of Liège, of which M. Gustave Carels is President.

## DESCRIPTION OF THE MARIEMONT AND BASCOUP COLLIERIES.

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(PREPARED UNDER THE SUPERINTENDENCE OF THE MANAGING DIRECTOR,  
M. L. GUINOTTE.)

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### I. GENERAL DESCRIPTION. (*See Map, Plate 54.*)

These two collieries, whilst completely distinct as to working and management, are united under a single head office. The former owns a royalty of 1480 hectares (3650 acres), the latter of 2410 hectares (5950 acres); making a total of 3890 hectares (9600 acres). The number of workable seams of coal is seventeen, varying in thickness from 0·40 m. to 1·70 m. (1·31 ft. to 5·57 ft.) The coal is specially suited for steam raising and for household purposes. The total out-put is about 1,000,000 tons per annum, divided equally between the two collieries. There are ten pits in the Mariemont, four in the Bascoup colliery. Many improvements in coal working have been invented or adopted at these collieries, of some of which a brief account will be found below.

The central office of the two Societies, as well as the special office of the Mariemont colliery, is situated at Mariemont; the special office of the Bascoup colliery is at Bascoup. The two are united by telegraph and telephone. In collieries of such extent as these the multiplicity of workings adds considerably to the cost of management, and also renders difficult the mixture of coal which is often required by the purchaser. The Society have solved this problem by forming a central establishment called the Triage Central, for screening, loading, and despatching. To this centre all the pits send their out-put by means of a system of endless-chain haulage. With the same point are also connected the repairing shops and stores of all descriptions. This establishment was erected in 1873. The system of endless-chain haulage, though known for many years

about Burnley and elsewhere, and largely used on the Continent, has nowhere been applied on so large a scale as here. It consists simply of an endless chain lying on the wagons, and passing at one of its extremities round a driving pulley, and at the other round a return pulley. Originally the driving pulleys were of cast iron, with recesses in the circumference to fit the links of the chain. This system had serious disadvantages. As the chain lengthened in work, its links no longer fitted into the recesses; hence arose slipping, violent shocks, and rapid wear both of the chain and of the pulley. M. Briart has completely remedied this by screwing into the rim of the pulley moveable steel grips, the position of which can be altered by a turn of the screw so as to suit the lengthening of the links.

The establishment of this automatic haulage necessitated the installation of a complete plant for emptying and classifying the coal, and for loading it on trucks, giving it at the same time a thorough cleaning.

Classifying has been carried out by the employment of screens with moveable gratings, invented by M. Briart. Every system of screening must satisfy the following main conditions:—

- (1) The different sizes of coal must be completely separated.
- (2) The coal must be preserved from breakage.
- (3) The work must be rapid and cheap.

Ordinary fixed screens placed at an angle may satisfy some of these conditions, but not all. If the angle is low, the coal does not break, but the separation requires a considerable amount of manual labour. The work is also slow, and the screens, if the out-put is large, must be very numerous. If the angle is high, the coal falls more rapidly, but it thus gets broken, and the proportion of large coal and rough slack is diminished. Moreover the separation is imperfect.

Various systems of screening have been invented to overcome these difficulties. In England and Germany cylindrical screens are largely employed. They work well as to separation and rapidity, but if the coal is friable the breakage is large. M. Briart has adopted another principle, which prevents any breakage, whilst

effecting the complete separation of the different sizes, and largely diminishing the manual labour. The apparatus consists of one or more gratings placed at a slight inclination one above the other, and working in the same way. Each is formed by a row of fixed bars and a row of moveable bars, which when at rest lie in the same plane. The moveable bars are fixed lengthways in a frame, which at its lower extremity is carried on two cranks, and at its upper extremity on two eccentrics keyed upon a rotating shaft. The moveable bars are above the fixed bars during one semi-revolution and below it during the other. During the former they have a longitudinal motion downhill, during the latter a similar motion uphill. Hence, when a coal wagon is emptied upon the upper part of the screen, the coal is first lifted by the moveable bars and carried downwards; it then rests on the fixed bars during the lower semi-revolution. At each revolution the coal is thus shaken up throughout its mass and gradually screened. All the small coal falls through the spaces between the bars, whilst the large coal is brought to the bottom without any shock, by a succession of steps. If necessary, both sets of bars can be made moveable.

If there are to be three classes of coal, two screens will be required. The first separates the large coal from the rough slack; the latter, which falls through, is received upon a frame which carries it upwards to the top of the lower screen, and on this it is separated into rough slack and fine slack. This lower screen may be placed horizontally, which enables the height of the discharging road above the rails of the delivery road to be lessened. This height has been fixed at 6 metres (19·7 ft.).

Experiments made on coal screened by the old and the new method have given the following results:—

	Mechanical Screening. Per cent.	Hand Screening. Per cent.
Large coal. . . . .	16·35	13·15
Rough slack . . . . .	32·63	31·08
Together . . . . .	48·98	44·23
Fine slack. . . . .	51·02	55·77
Total . . . . .	<u>100·00</u>	<u>100·00</u>

In the more recent examples, by simply turning a handle, without stopping the apparatus, it is possible to vary the distance between the bars of the screens, so as to alter the character of the screening. There are also mechanical means for cleaning the coal, and for delivering the screened coal into wagons without its falling from any height. The yield is thus increased, and the manual labour much diminished.

The screening shops, of which there are three, are all on the same plan. They are large rectangular buildings of three stories. The ground floor is on the level of the railway; the first floor contains the screens and loading apparatus; and the second floor the apparatus for emptying the trucks. The appliances for classifying the coal are placed at the two sides. They consist of turn-tables, or traversers, which bring the screened coal from under the screens to be cleaned by hand. From these the coal is carried to the railway wagons by special apparatus.

The trams from the pit are brought by the endless chain to a set of sidings on the uppermost floor of the shop. Each siding ends in a tipping cradle or "culbuteur," placed above one of the screens. This consists of two rings tied together by cross pieces and resting on four pulleys. The tram enters at one end and goes out at the other. Whilst in the cradle it is turned over sideways, and empties its load without shock upon a circular table which spreads the coal over the full width of the screen. The trams on leaving the tipper are carried forward by endless chains worked by the main engine to sidings running on each side of the building; by these they are returned to the yard at which they arrived, and so to the mine. The railway wagons which receive the coal stand on the platform of a weighing machine, so that the weight is known as soon as the wagon is filled.

The system of tramways which connects the various pits with the screening shops is connected by means of the winding engines with a similar system underground, also worked on the endless-chain principle. This underground chain system has a length of more than 9 kilometres on the whole (5·6 miles). Three methods have been used for working the chains. The first consists of a small steam

engine and boiler placed inside the mine. In the second, motion is transmitted from above ground by an endless rope, passing over a pulley at the surface, worked by a steam engine, and going down the shaft. At the bottom this rope passes round another pulley, and drives, through a second pulley keyed upon the same shaft, the underground hauling chain. In the third or automatic system, the full trams are brought down to a level below that at which the coal is got, and the power given by their descent is used for haulage on the horizontal roads. Inclined planes are provided, down which the full trams run; and the energy thus obtained is sufficient not only to draw up the empty trams, but to propel the full trams along the level road as far as required. The work of hauling is really done by the winding engine, which has to raise the coal from a greater depth.

All the underground roads are on iron cross sleepers of the Legrand system. The trams contain 5 hectolitres ( $17\frac{1}{2}$  cub. ft.); they are built entirely of steel, and are supplied with grease boxes on the Koepe system.

The total power used in the two collieries is not less than 5200 H.P., produced by 111 boilers, and utilised by 78 engines, stationary or locomotive. A special department, called the Division du Matériel, looks after the whole organisation, commercial and industrial, both as regards the workmen employed and outside customers. There is a special office for design and experimenting, in which all the apparatus, &c., is designed in full detail; the contractors having nothing beyond the task of construction.

The chief matters of interest at the pits are as follows:—

(1) The ascent and descent of the workmen, which is carried on by means of a man-engine or Fahrkunst. This is worked by means of a hydraulic balance invented by M. Abel Warocqué. It has a stroke of 3 m. ( $9\cdot84$  ft.). The platforms on each rod are 6 m. apart ( $19\cdot7$  ft.), and the speed is 8 strokes per minute. The speed of ascent is thus 24 m. per minute ( $78\frac{3}{4}$  ft.), so that it requires 20 minutes to ascend or descend through 500 m. As this speed is somewhat slow, a special improved apparatus has been erected at No. 5 pit.

(2) The winding engines are all provided with the variable

expansion gear of M. Guinotte. This consists of two valves, one on the back of the other, as in the Meyer system, but the expansion valve is a simple slide fixed to the valve-rod. The variation in the expansion is given by varying the radius and angle at which the eccentric is set upon the shaft; and it is obtained by means of a link-block moving in a link, which is worked by two eccentrics. The different positions of the link-block correspond to different degrees of expansion.

When this system is applied to engines running both ways, the link is worked by a single eccentric set suitably for either direction, and the second eccentric is replaced by a motion regulated by the valve-rod of the main valve. For winding engines the link-block is worked by a special gear, which varies the expansion in accordance with the variation of the resistance. In several of the winding engines the reversal of the valves is effected by means of the special steam-gear called the *Servo-Moteur*.

(3) The guides within the shaft, as lately re-constructed, consist of Vignoles rails, which are placed in pairs and fixed to a series of girder irons placed one above the other across the centre of the shaft. This system is found to give much fewer accidents and to cost much less in maintenance than the old guides of wood.

The above is only one example of the substitution of iron for wood. Amongst others may be mentioned sleepers on the underground roads, pulley frames, and ventilating doors. Steel ropes have also replaced, in recent instances, the ropes of alge fibre previously in use.

In most of the pits the ~~descending cage of empty trams is received at the pit bottom upon a balanced platform: as soon as the lower floor of the cage has been loaded with a full tram, the platform is overbalanced and the cage is let down gently by a brake till its upper floor comes to the level for charging.~~ <sup>descending cage of empty trams is received at the top, is received upon a balanced platform of two stories, the lower of which is already loaded with return trams. The weight of the cage causes the platform to descend and brings the cage down to the discharging level.</sup>

(4) The pumping engines are not remarkable, except in the case of pit No. 5, described below.

(5) The ventilators, ten in number, are all on the Guibal system, generally 9 m. in diameter and 2 m. wide (29.5 ft. and 6.6 ft.). Three pits possess two fans, to provide for possible accidents.

A special apparatus, due to M. Briart, and known as the Clapet d'Aérage, allows two of the winding pits to be used as upcast shafts

for the purpose of ventilation. It consists of a strong wooden partition fixed immediately below the reception platform, and of a depth somewhat greater than that of the cage. The pit is thus divided into two compartments, just large enough to receive the cages. The cages form, as it were, pistons in these two compartments; and whilst they are in them, the entry of external air into the shaft is almost completely cut off. At the receiving platform there are two traps, or moveable covers, which, when the cages are in the shaft, lie over the pit and prevent the entry of air. The ropes of the winding engine pass through holes in them. These covers are raised in guides by the cages when they reach the top, and are left behind on the top of the shaft when the cages descend. Below the partition is an air-drift communicating with the ventilator. By this arrangement it will be seen that the shaft is always closed either by the cages or by the covers, so that the external air cannot enter, and the ventilator can only draw the air from the mine. The closing of the pit is not of course absolutely complete, but the air which enters through the holes left for the ropes, &c., is insignificant in quantity. This system has worked well for more than fifteen years.

The timber employed underground is always ordered to definite dimensions, which are always kept in stock, so that exactly the quantity necessary can always be supplied. This system is found to offer great advantages in the way of economy.

There is a complete railway system worked in common by the two collieries, which conveys the out-put to the station at Bascoup-Chapelle. It is worked by five main-line engines and five shunting engines. There is also a wharf at Bellecourt and another at Mons. To unload the coal at these wharves, it is conveyed in sheet-iron wagons, each consisting of five rectangular boxes placed side by side. These boxes can turn on a hinge at one side, and are lifted at the other side by means of a small steam-crane. The side next the hinge opens from the bottom on withdrawing two bolts, and by tipping each box in succession its load is discharged through a hopper into a barge. By this arrangement a barge of from 60 to 70 tons can be loaded in less than half an hour.

For carrying coke and patent fuel, hopper wagons are employed. They are of sheet iron, and comprise three hoppers square at the bottom, with openings below the frame. The bottoms are closed by covers, which can be withdrawn by a rack. The wagon is covered at the top to protect the contents from wet. It has a special coupling, which enables the wagons to be coupled without the workmen passing between them. This system is due to M. E. Peny and to M. Mabile.

## II. MARIEMONT COLLIERY.

This colliery has a royalty of 1480 hectares (3660 acres), partly within the Forest of Mariemont. There are eighteen seams of coal. They lie with a tolerably regular dip towards the south, and are worked by various methods according to circumstances. The out-put is about 500,000 tons per annum from six pits, the amount varying between 522 tons per day at the St. Arthur pit, and 100 tons per day at the Le Placard pit. The situation of the pits is shown on the map, Plate 54.

The endless-chain haulage system, which connects all these six pits with the Triage Central, has a total length of more than 5300 metres (3·3 miles); it is likewise shown on the map. The district is much cut up by roads and railways, which presented considerable obstacles in the laying out of the haulage system; on the other hand, the whole of the surface is the property of the Society. Amongst the principal works of the system may be mentioned a tunnel 107 metres long (117 yards), by which the haulage road passes under the railway from Baume to Marchienne; and another tunnel of 72 metres (79 yards), passing under the Montaigu Road. These tunnels are circular in section, of 2·75 metres diameter (9 ft.). There is also an iron suspension bridge, by which the Placard section is carried across the boilers, sidings, &c., at the Triage workshops, and over a road. It consists of two suspension spans of 36·20 and 37·30 metres (119 and 122 ft.), and of two fixed spans of 12 and 20·50 metres (39 and 67 ft.).

The Triage workshops just mentioned have been described in the first section. The coal-washing apparatus is on the system of

Lührig and Coppée, the same as at No. 5 pit described below. The patent-fuel works, which are adjacent, are arranged to yield 250 tons of fuel bricks per day: the system is that of M. Bouriez with some modifications. The coal comes to them still wet from the washers, and comprises nothing but fine slack below 5 mm. diameter. It is raised by a Jacob's ladder, and deposited on a band of sheet-iron plates, inclined at  $20^{\circ}$ , which carries it slowly to a wooden tower divided into six compartments and capable of containing 200 tons. From the tower it is delivered by screw distributors to six hydro-extractors on the system of M. Briart. This hydro-extractor has its axis horizontal, and has the usual screw for the delivery of the coal; but the water escapes through a narrow slit, extending the whole way round the extractor. The coal falls into a conical drum, with steep sides, and slips down into a second cone, containing the regulating screw; a second drum, revolving at a different speed, receives it from the screw, and delivers it at the circumference, whilst the water escapes by the opening between the two drums. The difference in speed always keeps this opening clear. The machine can be so regulated as to dry slack of any size at will.

From the hydro-extractors the coal passes to a dryer, consisting of a sheet-iron cylinder, having fixed plates riveted on the inside, and each occupying a quarter of its section. The coal falls from one plate to the next below, being swept off each by rakes revolving on a central axis at 50 revolutions per minute. The coal is thus mixed up and falls as dust into the smoke coming from a furnace placed below the dryer. This smoke dries the coal whilst gradually getting moistened itself.

From the dryer the coal passes to the hydraulic presses, which have an improvement due to M. Guinotte. Between the compressing pistons and the cranks which work them are placed two hydraulic cylinders communicating with each other; in these the pressure is maintained constant by means of a loaded plunger. The result is that the cranks are double-acting, instead of single-acting as in the ordinary presses.

The steam-engines working the washers and pressers have a variable expansion on the Guinotte system. The governor acts

on the expansion valve through a simple mechanism called the *Servo-moteur cinématique*. This system solves the problem of applying the governor to give any required grade of expansion with as great regularity as in a Corliss engine.

Close to the Triage works is the store for bricks, mortar, &c., together with brick-making machines and mortar mixers.

The St. Arthur pit is the most important of those in the Mariemont Colliery. Its daily out-put is from 500 to 600 tons. There is a winding engine of 200 HP., a pumping engine of 600 HP., a man-engine of 110 HP., and a Guibal fan of 9 metres diameter ( $29\frac{1}{2}$  ft.). It comprises three shafts all in brickwork. Of these the first is a winding shaft in two compartments, 510 metres deep (1673 ft.); the second is a similar shaft, which is used both for winding and for the ascent and descent of the workmen; the third is an upcast shaft 386 m. deep (1266 ft.) and 2.40 m. in diameter (7.87 ft.). As explained in the first section, the whole of the coal is wound from the lowest level, at 476 m. (1561 ft.), although two higher levels are worked; from these the coal runs on inclined planes down to the lowest level. At the mouth of the pit are a number of large rooms warmed by stoves, and containing chests in which the men can keep their tools and clothes. The other pits belonging to the colliery are the St. Henriette pit (of which the arrangements much resemble those of the St. Arthur pit), Réunion, Abel, L'Étoile, and Le Placard pit. The last is the only pit belonging to the Society where the men are raised and lowered in cages.

### III. BASCOUP COLLIERY.

This colliery has a royalty of 2410 hectares (5955 acres), lying to the west of the Mariemont Colliery. The out-put is 500,000 tons per annum; of which about one-half comes from pit No. 5, which lies apart from the others. This pit delivers 800 to 1000 tons per day. It comprises a winding engine of 150 HP., two pumping engines of 400 HP., a man-engine of 40 HP., and two Guibal fans of 9 metres ( $29\frac{1}{2}$  ft.) diameter. There are also twelve boilers, warmed rooms for the men, screening shop, and coal-washing apparatus. There are

three circular shafts; of which the first is 4.25 metres diameter (14 ft.), and is used for pumping and for the men; the second of the same diameter is used for winding, and the third of 3 metres diameter (10 ft.) is used for ventilation. The third pit can however be utilised for winding, if required, by closing its mouth with covers, in the manner described in page 576. In all these pits it was necessary to sink, close to the surface, through a layer of sand about 30 metres thick (100 ft.), filled with water. This was done by the pressure process, a column of cast-iron tubbing being driven right through the sand by means of screw presses until it penetrated about 1 metre into the coal-measures. This column was formed of whole rings, turned and bolted to each other, as in the Chaudron system; and at the bottom were cutting edges, which excavated to a diameter 0.25 m. (10 in.) greater than that of the finished pit. There were eight screw presses bearing against a solid scaffold erected above the shaft, and supporting the different tools required for the sinking. It was also loaded by pig iron to a weight amounting, towards the end of the operation, to 450 tons. The tubbing was sunk direct into a seam of coal of great thickness; and as this was very unfavourable for closing the tubbing in the open air, compressed air was employed, and succeeded perfectly. From thence the shafts were sunk to the depth of 95 m. (312 ft.), all below the tubbing being bricked.

The great quantity of water which was expected induced the Society to provide two pumping engines, which with other motors are placed in the engine house. The two engines together deliver half a cubic metre per stroke, or, at the ordinary speed of 10 strokes per minute, a total of 6000 cb. m. in 10 hours (212,200 c. ft.). They are rotary engines with a high grade of expansion, cutting off at not later than one-tenth of the stroke; but each has only one cylinder, as M. Guinotte considers, contrary to the common opinion, that the compound system is not the most advantageous for such engines. The pumps are so arranged that the main rod always works in tension, the plunger being fixed while the pump barrel moves. The main rod consists of a single round bar of iron, going the whole depth of the pit, and not requiring any guides. There are three lifts of pumps, the height of each being 80 to 85 m. (260

to 280 ft.) The rod is attached direct to one end of the engine-beam, the other end of which is worked by the steam cylinder. From the piston-rod is hung through links a counterweight, which allows the cylinder to be double-acting whilst the pumps are single-acting. The foundations consist of an immense bed-plate of cast iron, 5 m. in height (16·4 ft.), and are much more solid than if built either of brickwork or of masonry. The advantages of the arrangement are the following. First, the beam is always subjected to the same stress, namely that due to the main rod itself, and to the column of water raised. This stress is always in the same direction, whether on the ascending or descending stroke, so that the beam is protected from that reversal of strains which so often produces the deterioration and final rupture of such structures. Secondly, the rods connecting the piston to the beam are under the same conditions as the beam itself. Thirdly, the whole pressure exerted by the steam on the piston is subdivided into three portions : one is passed to the beam through one set of rods, another to the fly-wheels through a second set of rods, and a third to the counterweight through the links. Each of these connections has only a moderate strain to support, the full strain coming upon the piston-rod alone. The distribution of steam is by means of piston slide-valves, and the expansion is on the system of M. Guinotte.

The man-engine is on the system of M. Warocqué, but with special improvements by M. Guinotte. The objections to the former system were as follows :—

I. The stroke was necessarily small, and the number of strokes per minute was limited by the necessity of preventing any shock at the beginning or end ; hence the speed of ascent or descent was slow.

II. The steam was always acting at full pressure, and the waste of fuel was therefore large.

III. The valves were worked by the engine-man ; hence the stop at the end of each stroke was not always exactly the same, and any inattention on his part might produce too sudden starting and stopping : this was another reason why the speed had to be slow.

These objections are all remedied in the present man-engine. The rods with their platforms are, as before, suspended from two plungers always in hydraulic balance: but equilibrium is obtained, not by a direct communication between the two cylinders, but by an intermediate crank-shaft, to which the plungers of two pumps are connected. Each of these pumps communicates with one of the cylinders of the hydraulic balance, and the cranks are so arranged that one pump is delivering into the balance at the time that the other is drawing from it. Since the strokes of the pistons in the pumps and in the hydraulic balance are inversely proportional to their areas, a crank of ordinary throw suffices to give a long stroke to the rods. Here the effective stroke of the rods is 5 m. (16·4 ft.), while the cranks have a radius of only  $\frac{3}{4}$  m. ( $2\frac{1}{2}$  ft.). The pumps are worked by an ordinary rotary engine making 10 revolutions per minute; the pump shaft makes only 1 revolution per minute, being connected by gearing. This engine has the Guinotte system of variable expansion worked by the governor.

The speed of ascent and descent has by this means been doubled, whilst at the same time the men have ample time for stepping across from one platform to the other. No unpleasantness results to the men, because the rods move as if actuated direct from the cranks, and therefore the speed becomes considerably slower at the dead points—that is at the starting and stopping. Moreover the platforms always come exactly opposite each other, so that the men pass across readily from one to the other. The steam consumed is much reduced by the employment of expansion; the saving is estimated at 75 per cent. A similar man-engine is in course of erection at the Réunion pit, with a stroke of 6 metres (19·7 ft.).

There is a steam capstan, which calls for no special remark beyond mention of the dead-weight brake which it carries, and an arrangement which allows the overhead pulleys to be shifted so as to serve one or other of the three compartments in the pit. The winding engine is a vertical two-cylinder engine, with automatic variation of expansion and with a steam-brake. It works a round steel rope wound upon cylindrical drums: the overhead pulleys are of wrought iron and consequently very light: the guides in the shaft are of iron.

The underground haulage deserves special mention; the principle is the same as in the other pits, but the arrangements are much simplified. On each side of the shaft at the level of 240 metres (262 yards) a chamber is excavated for loading the trams into the cages. From each of these chambers start two rising inclines, each with a single track, one towards the north and the other towards the south. The two northern inclines meet at a point situated at the level of 150 metres (164 yards), and the two southern inclines also meet at the same level. At these two points of meeting are placed the motor pulleys of the automatic haulage. These points are on the line of the main hauling roads which run east and west from each of the motor pulleys. The self-acting inclines to the shaft are worked by two endless chains passing round the semi-circumference of the motor pulleys: the full trams descending on the one side, and the empty trams ascending on the other. The chains pass round return-sheaves placed at the two extremities of the chambers above mentioned, and cross the shaft without interfering with the cages or with any of the operations within it. The length of the northern system is 1300 m. (1420 yards), and of the southern system 490 m. (535 yards.)

The screening shop at No. 5 pit comprises three sets of apparatus: one is a revolving circular table carrying a grating, the two others are on the same plan as those at Mariemont, and separate the coal into five classes. They have a special arrangement which allows the distance between the bars to be altered, and are so placed that the similar products coming from the two sets of apparatus can be brought together. The finest coal goes to the washing machine; the other classes are taken direct to the wagons on moving bands, the cleaning being done by hand as they go. Each apparatus is able to screen 120 tons per hour. At times of pressure this single pit has furnished in one day as much as 2100 tons, with one set of screening apparatus only.

The coal-washing apparatus is on the system of Lührig and Coppée.\* The small coal is raised in a Jacob's ladder, and thrown

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\* See Paper on Coal-Washing, Proc. Inst. C.E., vol. lxx., p. 134.

on a perforated iron table, which is shaken violently, and so subdivides the coal into four classes of different sizes. The first two of these are washed in ordinary tanks, the others on the felspar screens of the Lührig system. After washing, they are brought together again and delivered as one lot. The finest dust is sometimes delivered separately. The yield of the washing apparatus is 40 tons per hour.

The other pits of the Bascoup Colliery are the St. Catherine, No. 3, and No. 4. The number of seams worked is sixteen. There is an automatic haulage system leading from each pit to the Atelier Central de Triage at Bascoup, and comprising a tunnel 272 m. long (297 yards), which passes under the workmen's village at St. Catherine. The water from above the 210 m. level is collected and carried in a tunnel driven for the purpose to No. 5 pit, where it is pumped. The water from the lower levels is pumped from No. 4 pit. The Atelier Central de Triage has six sets of screening apparatus, and is lighted by Gramme arc-lights outside, and by Edison incandescent lights inside. If this lighting is successful it will be extended to the other establishments.

#### IV. WORKMEN'S INSTITUTIONS.

These collieries have for a long time made a special study of the material, intellectual, and moral welfare of the numerous workmen whom they employ. In 1872 was founded, by the late M. Arthur Warocqué, the Industrial School at Morlanwelz. This school has now more than 350 scholars, who receive free education, comprising mathematics, drawing, mechanics, physics, mining, &c. The courses of lectures are given by the engineers of the collieries, and the certificates conferred by the school are highly appreciated by the workmen. The Societies have also organised a sanitary service, and have done their utmost to encourage the formation of school-clubs and of co-operative stores. The sanitary service is under the direction of a committee composed of delegates from the management, from the medical men, and from the workmen. There is a special benevolent fund belonging to these collieries, which in 1882

distributed to sick or injured workmen a total sum of 40,710 francs. The co-operative stores and the workmen's benefit club are not confined to these collieries alone, but are absolutely free; each being managed by a committee appointed by the shareholders. In addition, a large number of saving clubs exist in the collieries, and are worked entirely by the men themselves. There is a pension fund established on the same basis as the State pension funds, and managed by a Committee composed of members of the colliery staff.

With regard to workmen's dwellings, the Societies have given all possible encouragement to the purchase of land and building of houses by the workmen themselves; giving them for this purpose advances of money without interest, and repayable upon easy terms. They have also built numerous houses, large and convenient, which they let at very reduced prices. The success of these endeavours is shown by the fact that 22 per cent. of the adult workmen are now proprietors of the houses they occupy. The Society of Mariemont owns 280 houses for workmen, and the Society of Bascoup 270, containing together a population of 3000 souls. Each house consists of a large living-room with a kitchen and a bedroom on the ground-floor, two bedrooms on the first floor, and some out-buildings. They are scattered in groups of two, four, or six, and do not take the form of a town, for which the workman often evinces a certain repugnance. Each house has its own garden, which the tenant keeps with the greatest possible care. They are all lighted by gas, the cost of fittings being borne by the Society. The employment of women underground was some years ago put an end to by the Society, without waiting for a law on the subject.

The General Manager is M. Lucien Guinotte, the Mining Engineer M. Briart, the Mechanical Engineer M. Weiler, and the Locomotive Engineer and General Secretary M. Peny.

## NOTES ON BELGIAN RAILWAYS.

By M. PAUL TRASENSTER, OF LIÉGE.

The law authorising the first Belgian railways was passed on 1st May, 1834. They were, excepting some lines in France, the first on the Continent. Two great lines were sanctioned: the one running north and south, from Antwerp through Malines and Brussels to Mons; the other east and west, from Ostend, through Bruges, Ghent, Malines, Louvain, Liége, and Verviers, to Herbesthal.

The first line was opened on 5th May, 1835, from Brussels to Malines, a length of 20,395 metres (12·6 miles). The following figures show the further development of the Belgian railways.

31st Dec. 1840.—State lines, 333·8 kil. Companies' lines, 32·3 kil.

„	1850.—	„	624	„	„	273	„
„	1860.—	„	748	„	„	980	„
„	1870.—	„	868	„	„	2028*	„
„	1881.—	„	2888	„	„	1294	„

Of the total 4182 kilom., 1154 kilom. were built by the State, 1409 kilom. built by Companies and bought afterwards by the Government; and 325 kilom. were built by Companies and bought by the State, but with an annual sum still to be paid to the Companies.

Belgium has more railways than any other country compared with its area. Per 1000 square kilom. there are 138 kilom. of railway in Belgium, 92 in Great Britain, 62 in Germany, 48 in France, and 16 in the United States.

The rates of transport are very low, on account of the Government being continually urged to lower them. It is an admitted principle that the charge for conveyance should be exactly equal to the cost, without any profit for the State. It is even open to discussion whether

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\* Between 1870 and 1880 many lines were bought by the State.

the charge should include the gradual extinction of the capital, as the Minister of Finance wishes it to do.

The fares are as follows for ordinary trains :—1st class 1·18*d.*, 2nd class 0·88*d.*, 3rd class 0·59*d.* per mile. For express trains add 25 per cent. to the fare for ordinary trains. Return tickets, issued for two days when the distance is over 75 kilomètres (45 miles), for one day when less, are 20 per cent. less than the price of two single tickets.

There are special low fares for certain classes of travellers, e.g. students and workmen, 0·185*d.* per mile; commercial travellers, 0·28*d.* per mile.

Goods are divided, for freight purposes, into four classes.

Class IV. contains heavy goods,—stone, pig iron, coal, iron ore, &c.

Class III. contains more valuable goods,—iron and steel, rails, plates, bars, tyres, locomotives, grain, &c.

Classes I. and II. take manufactured goods: textile manufactures, engines and tools, for instance, are in the first class; zinc, copper, lead, wool, cotton are in the second.

The rate of freight diminishes proportionately with the distance, by the following formula:— $\text{Freight} = f (\text{constant}) + na + n'a' + \dots$  Here  $n n' \dots$  are different numbers of kilomètres,  $a a' \dots$  are numbers of francs per tonne-kilomètre. These numbers are as below:—

	<i>f</i>	<i>n</i>	<i>a</i>	<i>n'</i>	<i>a'</i>	<i>n''</i>	<i>a''</i>	<i>n'''</i>	<i>a'''</i>	<i>n''''</i>	<i>a''''</i>	Minimum Charge.
	fr.	km.	fr.	km.	fr.	km.	fr.	km.	fr.	km.	fr.	fr.
1st class	1·00	75	0·10	75	0·08	50	0·06	225	0·04	..	..	1·50
2nd „	1·00	75	0·08	75	0·04	300	0·02	..	..	..	..	1·40
3rd „	1·00	75	0·06	25	0·03	25	0·02	300	0·01	..	..	1·30
4th „	0·50	25	0·06	50	0·04	25	0·02	250	0·01	75	0·02	0·50

The rates do not extend beyond 425 kilomètres (265 miles), as this is the longest distance from one end to the other in Belgium.

The following is an example:—

For a distance of 100 kilomètres, 4th class. Freight = 0·50 +

$25 \times 0.06 + 50 \times 0.04 + 25 \times 0.02 = 4.50$  fr., or 0.045 per tonne-kilomètre.

For 200 kilomètres, 4th class. Freight =  $0.50 + 25 \times 0.06 + 50 \times 0.04 + 25 \times 0.02 + 100 \times 0.01 = 5.50$  fr., or 0.0275 per tonne-kilomètre.

For 400 kilomètres, 4th class. Freight =  $0.50 + 25 \times 0.06 + 50 \times 0.04 + 25 \times 0.02 + 250 \times 0.01 + 50 \times 0.02 = 8.00$  fr., or 0.02 per tonne-kilomètre.

It is to be remarked that, beyond 350 kilomètres, the rate per tonne-kilomètre remains constant at 0.02 fr., which is the minimum rate of the normal tariff.

For conveying coal the rates in different countries are given below:—

Kilo- mètres.	Belgium.	Prussia, State Railways.	Alsace and Lorraine.	Franco-Austrian Railways.	Eastern France.
	fr.	fr.	fr.	fr.	fr.
1	0.56	1.00	1.125	1.20	0.48
10	1.10	1.375	1.375	1.31	1.20
20	1.70	1.75	1.75	1.87	2.00
30	2.20	2.125	2.375	2.43	2.80
40	2.60	2.375	2.625	2.99	3.60
50	3.00	2.75	3.00	3.50	4.40
100	4.50	4.25	4.625	5.95	5.40
200	5.50	7.875	8.00	10.19	10.40

In addition to the normal tariff for internal traffic, the basis of which has just been described, there are on the State railways a great number of special low rates, intended to favour the exportation of Belgian products, the importation of certain raw materials, and particular classes of through traffic, e.g. that between the port of Antwerp and the countries bordering on Belgium.

Thus several classes of goods, which rank in the 1st, 2nd, or 3rd class for internal traffic, rank as 2nd, 3rd, or 4th class respectively when exported or imported by sea. Rails, bars, and other kinds of

finished iron, sent from Liège or Charleroi to Antwerp for export, are taken in the 4th class; and there are similar reductions in the classification of other classes of goods.

There are also special tariffs at very low rates for the exportation of coal *vid* Antwerp or to the north-east of France, for the importation of iron ore to the Belgian furnaces from the Grand Duchy of Luxembourg, for the conveying and exportation of the specular iron-ore of the Meuse basin, &c. The reduction is still further increased for quantities over 100 or 200 tons.

These rates are of great importance for the trade of Belgium; and it may be worth while to give some of the principal rates, as compared with what would result from the application of the normal tariff. The following are examples:—

		Dis- tance. Kilom.	Normal Rate. Fr. *	Special Rates.		
				10-ton Lots. Fr.	100-ton Lots. Fr.	200-ton Lots. Fr.
Ex. I.	Basis of rate . . . . .	<i>n</i>	F	$n \times 0.026$	$n \times 0.02$	..
	Liège to Antwerp . . . .	120	4.70	3.12	2.40	..
	Charleroi to Antwerp . .	100	4.50	2.60	2.00	..
Ex. II.	Basis of rate . . . . .	<i>n</i>	F	$F - 0.50$	$F - 1.25$	$F - 1.50$
	Luxembourg Frontier to Charleroi . . . . .	191	5.41	4.91	4.16	3.91
	Luxembourg Frontier to Liège . . . . .	167	5.17	4.67	3.92	3.67
Ex. III.	Basis of rate . . . . .	<i>n</i>	F	$F - 0.50$	$F - 1.25$	$F - 1.50$
	Liège to French Frontier .	166	5.16	4.66	3.91	3.66
	Bracquenies to French Frontier . . . . .	215	5.65	5.15	4.40	4.15
	Mons to French Frontier .	240	5.90	5.40	4.65	4.40
Ex. IV.	Basis of rate . . . . .	<i>n</i>	..	$1 + n \times 0.02$	..	..
	Sclaigneaux to Charleroi .	50	..	2.00	..	..

\* The normal rate F is calculated according to the formula  $F = f + na + n'a' + \dots$ , given above.

The rates in Ex. I. apply to coal, iron ore, stone, and phosphates, for exportation from Belgian ports. The minimum charge is 2·2 fr. per ton for 10-ton lots., 2·0 fr. for 100-ton lots.

The rates in Ex. II. apply to iron ore, imported from Luxembourg to the blast-furnaces of Liége and Hainault.

The rates in Ex. III. apply to coal exported to the east of France, *viâ* Athus or Lamorteau in Luxembourg.

The rate in Ex. IV. applies to iron ore carried from the Meuse to the Belgian furnaces.

Bilbao ore imported *viâ* Antwerp pays between Antwerp and Seraing 4·25 fr. instead of 4·75 fr. per ton.

There are other special rates, given to encourage through traffic, which are sometimes detrimental to Belgian trade; e.g., coke carried from the Ruhr, *viâ* Spa to Luxembourg, enjoys a reduction of 0·70 fr. per ton, compared with Belgian coke over the same distances; and gas-coal on its way from the Ruhr to Paris has an advantage of 1·75 fr. per ton over Belgian coal carried the same distance.

Each department of Government publishes a statistical report every year. From the industrial point of view the most interesting are the reports of the Minister of Public Works, giving a very accurate account of everything relating to the management of the railways, and also to the post-office, telegraphs, bridges and roads, mines, &c.

From the latest of these reports are taken the following figures, which show the importance of the various tariffs described above.

Of the goods carried in 1881 by the State railways, about 43 per cent. were carried at the normal tariff of Class 4; 14 at that of Class 3; 7 at that of Classes 1 and 2; and 36 per cent. at special tariffs. The mean rate per ton was 3·30 francs for a mean distance of 70 kilomètres. Had the normal tariff for the 4th class been applied throughout, the mean rate for the same distance would have been 3·80 francs.

A comparison with other nations will show that as regards cheap transport the State railways of Belgium are in an excellent position. A Report presented two or three years ago to the French Chamber

by M. Waddington, in the name of the Tariff Commissioners, gives the following as the passenger fares for third-class traffic in various countries:—

Norway . . . . .	3·2 centimes per kilomètre.
Belgium . . . . .	3·8   "   "
Southern Germany . . . . .	4·2   "   "
Northern Germany . . . . .	5·0   "   "
Italy . . . . .	6·2   "   "
Spain . . . . .	6·2   "   "
Great Britain . . . . .	6·2   "   "
France . . . . .	6·7   "   "
Hungary . . . . .	6·8   "   "

The average amount received, taking account of reduced fares, is as follows:—

Germany . . . . .	3·84 centimes per kilomètre.
Belgium . . . . .	3·88   "   "
France . . . . .	6·36   "   "
United States . . . . .	7·30   "   "

According to the same Report and other sources, the average rate per tonne-kilomètre of goods is as follows:

	Year.	Rates per tonne-kilomètre.	Mean distance.
		Centimes.	Kilomètres.
United States . . . . .	1879-80	4·0	178
Belgium (State Railways)	1881	4·7	70
Alsace and Lorraine . .	1876	5·6	89
France . . . . .	1878	6·0	132
England . . . . .	—	7·3	37

Making allowance for the greater average distance on the American lines, it will be seen that Belgium stands in perhaps the best position of any country.

Fig. 1. Plan.  
Scale 1 to 4000.

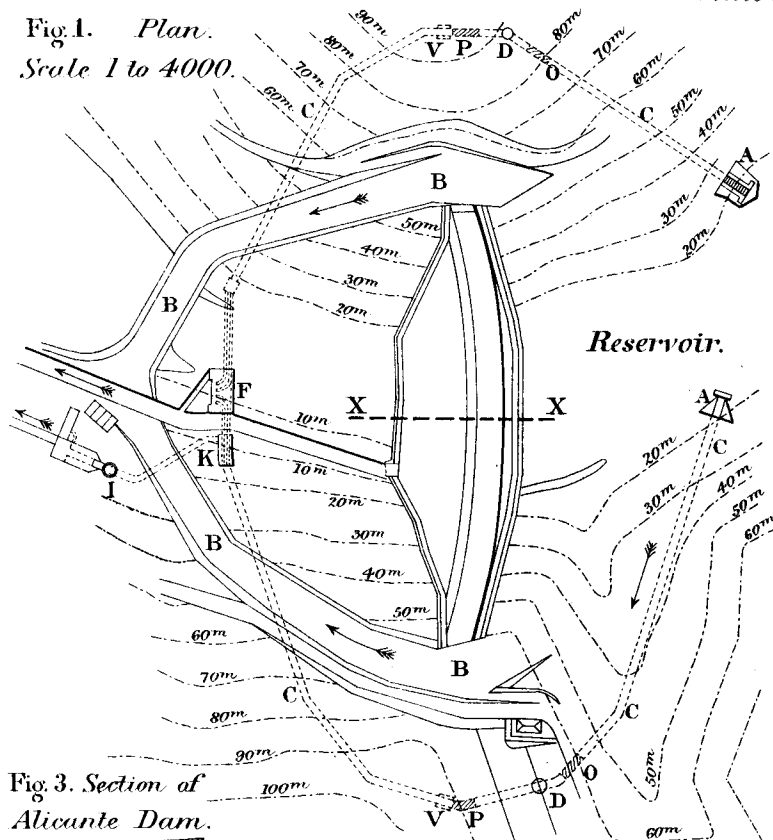


Fig. 3. Section of  
Alicante Dam.

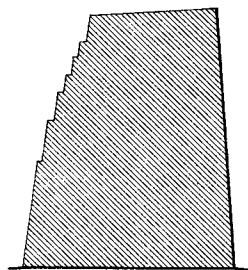


Fig. 4. Section of  
Furens Dam.

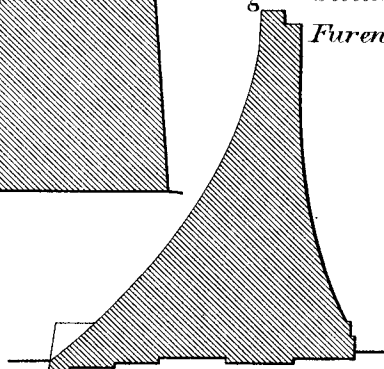
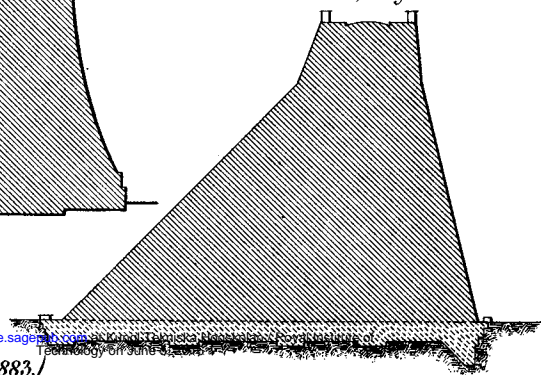


Fig. 2. Section at  
XX, Fig. 1.

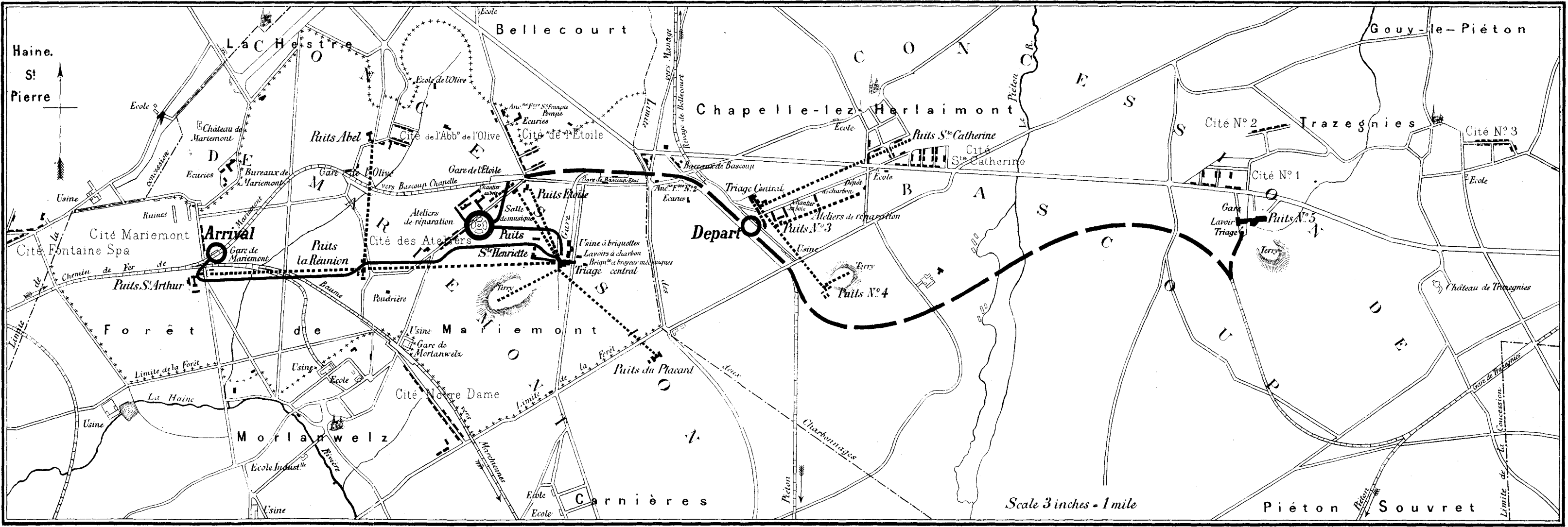


Scale for Sections,  
1 inch to 100 feet,  
or 1 to 1200.

# INSTITUTION OF MECHANICAL ENGINEERS, BELGIAN MEETING, 1883.

## PLAN OF MARIEMONT AND BASCOUP COLLIERIES.

Plate 54.



REFERENCES Chain Haulage arrangement (automatic)   
 Buildings belonging to the Society

Route on foot   
 Route by Special Train