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MR. H. T. PINNOCK IN THE CHAIR.

THE CHEMICAL INDUSTRIES OF GERMANY.

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It is remarkable that the Royal House of Prussia has during many centuries been associated in one way or another with chemical enterprises of various kinds. Thus already the second ruler of the country, the Markgraf John (1608—1619) was actually surnamed "the Alchemist" in consequence of the zeal with which during many years he pursued his investigations on the transmutation of metals, whilst a number of his successors exhibited great interest in the same problem—the manufacture of gold—which has never failed to fascinate the needy princes—and what princes are *not* needy?—of all ages and all nations. The Great Elector (1640—1688), who did so much to advance the power of Prussia, was a patron of chemistry, which was just then beginning to emerge as an *experimental science from the obscurantism* of alchemy. He provided the celebrated Kunkel with a laboratory and glass furnaces on an island in his park at Potsdam, and it was there that in 1678 Kunkel made the discovery of ruby glass, produced by means of traces of gold, and which is still an unsurpassed method of colouring glass for ornamental purposes. Kunkel also rediscovered phosphorus, which had previously, in 1669, been obtained by the alchemist Brand of Hamburg, who had quite accidentally produced it in the course of his attempts to extract the Philosopher's Stone out of urine. But whilst the discovery of yellow phosphorus is thus of German origin, its production on an industrial scale was, until 20 years ago, only carried on in England and France. In 1892 the manufacture of phosphorus by electro-thermic means was introduced into Germany by the Chem. Fab. Griesheim-Elektron at Frankfurt.* Red phosphorus was discovered by Schrötter, an Austrian chemist, in 1848, and was adapted for safety-matches by the German Böttger in the same year. His invention was first taken up in Sweden, and was not adopted until 10 years later in Germany. The match industry has assumed its largest dimensions in Germany. Thus the German annual production in 1912 was £4,000,000.† The value of all matches (British and foreign) consumed in Great Britain in 1910 is estimated at £1,293,750—about 9 matches per day per head. Messrs. Bryant and May's (by far the largest English concern) turned out 1152 million boxes in 1907. This represents about ¼ the British output. In 1907 the total value of British production was £775,000, of which £76,000 worth was exported.‡ The British export of matches is diminishing. It is worthy of note that Japan in 1901 exported matches to the value of £1,200,000.

Porcelain.—Another great German industry owes its origin to alchemistic studies made by Böttcher in the reign following that of the Great Elector, namely, that of Frederick III. (1688—1713) first King of Prussia. Having succeeded in making gold before witnesses, Böttcher was seized by order of the Elector of Saxony and was "interned" at Dresden, where, although he did not succeed in making the much-desired gold, he founded, along with the physicist Tschirnhaus, the celebrated Dresden porcelain industry.

The astute Frederick the Great (1740—1786) was anxious to manufacture the Dresden ware at Berlin and to this end commissioned his court apothecary, Johann Heinrich Pott, to institute investigations. These attempts were, however, all unsuccessful.

The Great Frederick placed much faith in secret agents and it was by means of spies that he succeeded in discovering the secrets of the Dresden porcelain manufacture, for at his instigation an enterprising merchant, bearing the name of Gotzkowski, with the assistance of a Saxon workman, brought the secrets of the Dresden process to Berlin and established a porcelain factory in the Leipzigerstrasse, which still remains the warehouse for the Berlin porcelain goods. But Frederick later stopped the pecuniary assistance with which the factory had been subsidised, and Gotzkowski was forced to sell the concern to Frederick for a sum of about £30,000, and so was established the celebrated Berlin Royal Porcelain Factory, amongst the products of which are the well-known crucibles and evaporating basins. The flourishing state of the German porcelain and pottery manufacture is attested by the fact that during the past 25 years the number of works has increased from 228 to 359, and the number of workpeople employed from 37,000 to 66,000. In 1912 the German exports of china, earthen and stoneware were valued at upwards of 3¼ million sterling.

Glass.—Even still more important is Germany's glass manufacture, for which she has long been pre-eminent. The annual export in recent years has been over seven million pounds.

Cyanide industry.—In the early 18th century an accidental discovery was made by Diesbach, a Berlin colour-maker, which has proved of great industrial importance. Diesbach was preparing what is known as Florentine lake, a red pigment obtained by precipitating a solution containing cochineal extract and an iron salt with caustic potash. It so happened, however, that the potash used by Diesbach had been in contact with bone-oil, containing some cyanide, and the result was that, instead of the result he anticipated, a magnificent blue colouring matter was obtained. This substance, which is still known as Berlin or Prussian blue, was the first cyanogen compound to be discovered.

The cyanogen compounds have played a most conspicuous part in the development of organic chemistry, and every source of cyanogen has been exploited for obtaining them. In recent years the demand has increased enormously owing to the employment of sodium and potassium cyanides in the extraction of gold. To meet this demand a number of synthetical methods for their preparation have been super-added.

Germany's annual production of cyanides is estimated at 10,000 tons, of value £650,000, or about half of the world's production.

Beet sugar industry.—Another industry also had its beginnings in the 18th century during the reign of the Great Frederick, and was the

* The author has much pleasure in acknowledging the assistance he has received from the valuable compilation by Professor Lepsius of Berlin, "Deutschlands Chem. Industrie 1888—1913," and from that by Dr. Duisberg, of Elberfeld, "Wissenschaft und Technik," 1911.

† Molinari, "General and Industrial Inorganic Chemistry," 1912.

‡ Clayton.

outcome of the laborious researches of Marggraf (born in Berlin in 1700, and a pupil of Stahl) on the occurrence of sugar in the vegetable kingdom. Of the numerous plants investigated from this point of view he found that the beetroot (*Beta vulgaris*) contained the largest proportion of saccharine material and that the sweet-tasting substance was identical with that present in the tropical sugar cane (*Saccharum officinarum*).

It was not, however, until some 50 years later that the observations of Marggraf led to the first beet-sugar factory in the hands of Franz Karl Achard, who was subsidised in this venture by the Prussian King, Frederick William III. (reign 1797—1840), who was also the founder of the University of Berlin.*

The beet-sugar industry had to contend with strenuous competition on the part of the cane-sugar manufacturers, who were chiefly English and who are said to have endeavoured to corrupt Achard by heavy bribes. The industry was, however, greatly promoted when, in 1806, Napoleon issued his famous edict closing the European ports to British goods. The vast extent of this industry at the present time can be gathered from the following figures:—

Total sugar crop for 1912-13: Cane sugar, 9,211,755 tons; beet sugar, European (one-third German), 8,310,000 tons; beet sugar, U.S.A., 624,064 tons; total, 18,145,819 tons.

The sugar industry should give us food for serious reflection when we consider the following facts:—United Kingdom spends annually £23,000,000 on 1,700,000 tons imported sugar. Germany produces £36,000,000 worth of beet sugar on 1,300,000 acres, France produces £13,000,000 on 570,000 acres; all continental countries together produce £116,000,000 on 6,000,000 acres.† In the United Kingdom there is only one small experimental beet sugar factory in existence. The beet sugar industry is of particular interest in connection with the present European crisis, inasmuch as it is a most notable example of an industry which largely owed its successful inception to a state of war which disturbed the previously established order of things in the matter of sugar-supply.

In this country agriculture is well known to be productive of a conservative frame of mind, but that it is not so in Germany is well illustrated by the extraordinary progress which has been made in the cultivation of the sugar-beet under the guidance of systematic scientific research. Thus in 1840 100 kilos. of beet gave 5·9 kilos. sugar; in 1850, 7·3; in 1870, 8·4; in 1890, 12·5; and in 1910, 15·8 kilos. In 1871 the mean production of beet per hectare‡ was 246 quintals,§ and in 1910, 300 quintals. In 1867 the consumption of coal for 100 kilos. of beet was 35 kilos.; in 1877, 24; in 1890, 10; and in 1900, 7 kilos. Further economy in coal has been effected by means of the Kestner concentrator.‖

Sulphuric acid, soda, and bleaching powder industries.—Sulphuric acid was discovered by the German alchemist Basil Valentine in the 15th century. The production of this fundamental acid, however, on any considerable scale took its origin in Birmingham, where Dr. Roebuck in 1746 introduced the classical leaden chamber process. At the beginning of the 19th century it became an industry of great importance, more especially in England, because of this acid being required for the manufacture of carbonate of soda by the Le Blanc process.

The manufacture of Le Blanc soda was taken up in England in 1814, especially in connection with soap-making, and it was in England that this manufacture assumed the largest proportions. The enormous advances made in this manufacture during the past century may be gathered from the fact that the price of carbonate of soda in 1818 was about £42 per ton, whilst to-day it is only about one-tenth of that amount. One of the determining factors which made England the principal home of soda manufacture was the great development of our cotton industry during the 19th century.

During a large part of the last century England manufactured Le Blanc soda, sulphuric acid, and bleaching powder* for most of the world. But during the latter half of the century the rival ammonia soda process made its appearance. The original discovery of the reaction on which it depends—it was first patented in England by Dyar and Hemming in 1838—is ascribed to several different persons, but the process was first made an industrial success in Belgium by M. Ernest Solvay. The Couillet Works were founded with a capital of about £6000 in 1863; the numerous affiliated works are now to be found in Belgium, England (Brunner, Mond and Co.), Germany, France, Italy, Spain, Austria-Hungary, Russia, and North America. They employ 35,000 persons. During the 50 years the price of soda has been reduced from £16 to £4 a ton. The displacement of Le Blanc soda by ammonia-soda involved the introduction of new methods of chlorine manufacture. After numerous abortive attempts in various directions, the successful production of electrolytic chlorine has been achieved, and about half of the bleaching powder in the world is now made by this means.

Electrolytic chlorine is now often converted into liquid chlorine (6d. a kilo.), of which large quantities are used at Stassfurth for the annual preparation of 500,000 kilograms of bromine, and the Badische Anilin und Soda Fabrik used in 1900 more than 1 million kilos. for the preparation of chloracetic acid employed in the manufacture of synthetic indigo.

In the manufacture of sulphuric acid, again, the old-established English or leaden chamber process has not been allowed to remain unchallenged, for since the beginning of the present century it has had to meet the competition of the so-called contact process. This is based on a long known reaction,† which, however, remained almost unutilised until the meticulous industry of German chemists and the courageous enterprise of German manufacturers developed it into a commercially successful process, which was elaborated in the works of the Badische Anilin und Soda Fabrik at Ludwigshafen.

The ammonia-soda and the contact sulphuric acid‡ processes, although carried out in this country, have been largely instrumental in making other countries, more especially Germany and the United States, independent of the English production of these all-important chemicals.

In 1882 the world's consumption of soda was 700,000 tons (160,000 am. soda), and in 1902 1,760,000 tons (250,000 Le Blanc). In England, in 1876, £7,000,000 was invested in the industry,

* There was no University in Berlin until 1809, but the following figures will show how Prussia has made up for lost time in this respect. In 1913-14, there were 7613 male and 770 female matriculated students, and 4113 male and 89 female non-matriculated students. The annual income was £240,310, of which £204,650 came from the State, £40,900 from fees, etc., and £760 from other sources. The annual expenditure was £246,310, of which the teaching staff accounted for £104,790; departmental expenses, £100,140; building expenses, £10,610; reserve, £6080; administration, bursaries, etc., £24,000. "Minerva," 1914.

† C. W. Fielding, "Morning Post," Jan. 23, 1915.

‡ Hectare=2·5 acre. § 1 quintal=100 kilograms.

‖ Molinari, "General and Industrial Org. Chem.," 1913.

* Discovered by Tennant in 1799.

† This reaction had for many years been used by Messel in England, but only for manufacture of SO_3.

‡ The Clayton Aniline Co. and Nobel's Explosives Works have contact sulphuric acid plant.

which gave employment to 22,000 workpeople. In 1880 the British output was 430,000 tons, and in 1896 800,000 tons. North America in 1886 produced 1100 tons, and in 1898 300,000 tons; and Germany in 1878 made 42,000 tons, in 1901 300,000 tons, and in 1910 400,000 tons.* The first soda works in Germany was only erected in 1843 by Hermann at Schönebeck, near Magdeburg, and the first leaden chamber by Kunheim in 1844 on the Tempelhof Plain, near Berlin.

Hydrogen industry.—The electrolytic production of soda and chlorine is of course attended with the evolution of enormous volumes of hydrogen. At first this gas was allowed to go to waste, but gradually interesting and important uses have been found for it; (1) Dirigible balloons, rendered possible by taking advantage of the lightness of the internal combustion engine. One horse-power engine is but little heavier than 1 kilogram. 27,000 cub. metres of hydrogen is required for a modern airship. The balloon sheds are often established near electrolytic soda works, or the gas may be transported in steel cylinders compressed to 150 atmospheres. 500 cylinders containing 2750 cub. metres of gas are placed on one railway wagon, and more than 8 such wagon-loads are required for the filling of a single Zeppelin. (2) Autogenous welding with oxyhydrogen flame. These most important applications of hydrogen were introduced at the beginning of this century by the Chemische Fabrik Griesheim-Elektron. The oxy-acetylene flame is now more commonly used. (3) Artificial gems by means of oxy-hydrogen flame. Some 30 years ago C. V. Boys succeeded in fusing quartz with the oxyhydrogen flame and then drawing it out into incredibly thin fibres, which have proved of the highest value for certain physical experiments of extraordinary delicacy. The same source of heat was much later, in the nineties, employed by the French investigator, Michaud, to reconstruct rubies from small fragments of this gem. At the beginning of this century Verneuil and Paquier, in Paris, succeeded in making synthetic rubies. A little later Wild, Miethe, and Lehmann in Germany elaborated methods for producing synthetic corundum, rubies, amethysts, and sapphires, which are manufactured by the Elektrochemische Werke at Bitterfeld. These products are identical in chemical composition and physical properties with the natural gems, and the rarest varieties of these can be obtained at will. Fused alumina (very pure) gives corundum; fused alumina + 2½% chromic oxide gives ruby; fused alumina + magnesia and titanium oxide and ferric oxide gives blue sapphire. These synthetic gems are now manufactured to the extent of about 6 million carats annually (1 carat = 0·205 gram), or 1230 kilograms or more than one ton. Experienced connoisseurs can, however, distinguish between the natural and artificial gems, with the result that the former have not diminished in value. Natural rubies or sapphires of 2—4 carats cost £20—£50, and larger stones up to £150, whilst the artificial would only cost 1/500—1/1000 of those amounts.

A still more recent and much more important application of hydrogen is for the hardening of fats, which depends on the transformation of unsaturated into saturated acids by means of hydrogen in the presence of a catalyst (nickel, palladium, etc.).

*Production in tons, 1910.**

	Germany.	England.	France.	United States.	Europe.	World.
Sulphuric acid (H_2SO_4)	1,250,000	1,000,000	500,000	1,200,000	3,700,000	5,000,000
(of this by contact process)	400,000			250,000		
Soda	400,000	700,000	200,000	250,000		2,000,000
(of this Le Blanc Soda)	30,000	120,000				150,000
Saltpetre consumption	786,000	93 000	337,000	523,000	1,740,000	2,360,000
(of this for nitric acid)	150,000			50,000		
Hydrochloric acid (30%)	450,000	†				
Bleaching powder	100,000					300,000
(of this electrolytic)	70,000					150,000

* Duisberg, "Wissenschaft und Technik," 1911.

† Already in 1895 the estimated production of hydrochloric acid in England was 1 million tons, and for the whole of Europe 2 million tons. (Molinari.)

Industries connected with artificial illumination.—The world is greatly indebted to Germany for inventions which have largely revolutionised artificial illumination, firstly, in connection with gas and more recently in respect of electric lighting.

Thus, one of the most remarkable discoveries in this domain was that of incandescence gas lighting, which was made by the Austrian Count Dr. Carl Auer v. Welsbach of Rastersfeld in Styria, as the result of lengthy, laborious, and ingenious researches. The now so familiar gas-mantles are prepared by the ignition on the cotton frame of a mixture of thorium nitrate, 99; cerium nitrate, 1%.

The source of these rare earths is monazite-sand, the elaboration of which has become a very important industry depending on fractional crystallisation, which already many years ago was brought to such a high pitch of perfection in the laboratory of Sir Wm. Crookes. Out of this monazite-sand, Otto Hahn, in 1910, succeeded in extracting mesothorium, and the process is carried out on a large scale at the works of Dr. O. Knöfler und Co., at Plötzensee near Berlin. Radium bromide is worth about £17 a milligram, mesothorium about £7 10s. a milligram. The mesothorium is only present in the monazite sand in extremely small proportion, about 1 part in 150 million parts of the mineral.

I may also refer to Auer-metal, a preparation of iron (Fe 30%) containing cerium, which sparks when scratched with hard steel, and which is familiar as a substitute for matches.

Electric light metallic filaments.—Another outlet for the use of hydrogen has been in reducing the rare-metals osmium (m. pt. 2500° C.), tantalum (m. pt. 2300° C.), and tungsten (m. pt. 2850° C.).

In 1903 the Auer Company showed that the carbon filament of incandescence electric lamps could be replaced by an osmium filament with an economy of 50—60% of current. In 1905, Siemens und Halske showed that a tantalum filament was cheaper and more advantageous, and in 1906 that the tungsten filament was even still better. Tungsten occurs in sufficient quantity in nature as wolframite (iron tungstate) and scheelite (calcium tungstate) to enable the metal to be now sold as filament-metal for 6s.—7s. a kilogram.

Some idea of the enormous and increasing scale on which the incandescence lighting manufacture

* Molinari.

is carried on in Germany may be gathered from the following figures :—

	1911.	1912.
Metallic filament electric lamps	47,211,892 pieces	76,185,721 pieces
Carbon filament electric lamps	24,791,196 "	20,975,348 "
Incandescence gas mantles	126,050,954 "	135,320,173 "
Arc-lamp carbons	10,740,025 kilos.	11,093,154 kilos.

According to V. B. Lewes, the consumption of gas-mantles in 1912 was :—Germany, 100,000,000 ; America, 60,000,000 ; England, 38,000,000 ; France, 16,000,000 ; Belgium, 3,500,000 ; Italy, 3,000,000 ; Russia, 1,500,000.

The special tax imposed in Germany on lighting apparatus realised from the above sources in 1912 was £800,000. This remarkable tax was one of those extraordinary financial expedients resorted to by Germany during recent years to provide the wherewithal for the stupendous national effort to subjugate Europe of which we are the witnesses to-day.

Ammonia.—Of the commoner inorganic chemicals which are produced on the largest scale, one of the most important is ammonia, which has for so many years been obtained as a by-product in the manufacture of coal gas.

So backward was this industry in Germany, that actually even as late as 1874 the ammoniacal liquor from their gas works was run to waste. All the more remarkable is the state of affairs to-day as betrayed by the following figures. The world production of ammonium sulphate was 210,000 tons in 1890, 500,000 tons in 1900, and 1,330,000 tons in 1912. Germany's production of ammonium sulphate in 1912 was about 370,000 tons.

The principal use of sulphate of ammonia is as a nitrogenous manure, as which it competes with Chili saltpetre: they may be taken as of equal money value per unit of nitrogen. In this connection Germany's manure bill is interesting :—

	1888.	1912.
	tons.	tons.
Chili saltpetre*	225,000	650,000
Sulphate of ammonia	50,000	500,000
Superphosphate	250,000	1,800,000
Basic slag	250,000	2,200,000
Crude potash salts	160,000	3,000,000
Lime	500,000 (Lime and Other manures together)	800,000
Other manures		500,000
Total value	....	£30,000,000

* The total import of Chili saltpetre into Germany in 1912 was 800,000 tons, of which only 150,000 tons was used for manufacture of potassium nitrate and nitric acid.

It is the ambition of the Germans, firstly, to make themselves independent of the industrial products of other countries, and secondly, to produce in excess of their own needs and to impose this surplus on the rest of the world. Thus, they pride themselves on displacing more and more of the foreign Chili saltpetre by home-made sulphate of ammonia, and in 1911 they used in agriculture 75,000 tons of ammoniacal nitrogen against 70,400 tons of foreign saltpetre-nitrogen. This partial success they look forward to making complete and decisive by developing new methods of producing ammoniacal nitrogen and nitrates which can be carried out in Germany. Of such methods there are already two in operation, and they are associated with that great problem which confronts mankind as a whole. How to supply the combined nitrogen which will be necessary to build up the food-stuffs for the teeming millions of the future, after the deposits of Chili saltpetre are exhausted ? This is the same problem as that of fixing the nitrogen of the air, which long ago, before anything was known of nitrogen at all, man had solved empirically by growing leguminous plants in the rotation of his crops, thereby increasing the fertility of the soil, although the mechanism of this time-honoured procedure was only experimentally demonstrated in the last decades of the 19th century by the German investigators, Willfahrt, Hellriegel, and Nobbe.

Fixation of atmospheric nitrogen by inorganic means.—This has been successfully accomplished by :—

(1) The Birkeland and Eyde electric furnace, and the Schönherr electric furnace of the Badische Anilin und Soda Fabrik. These are simply realisations on the industrial scale of laboratory experiments made by Cavendish 130 years previously. This method is applicable only in Norway or other countries where abundance of water power renders the production of cheap electrical energy possible. It is being carried on by an international company at Notodden in Norway. They propose to use 300,000 horse-power capable of yielding 150,000 tons lime-saltpetre (15—20% N) or about $\frac{1}{5}$ of the total amount of Chili saltpetre used by the world. Germany possesses but little water-power so that this process is of only indirect interest in connection with German chemical industry.

(2) Fixation of nitrogen by calcium carbide at high temperatures. This discovery was made by the German chemists Frank and Caro. £5,000,000 capital is already embarked in this industry by various companies of Europe and America. About 120,000 tons is produced annually, about one-quarter of which in Germany. The crude calcium cyanamide (about 20% N) may be used directly as a nitrogenous manure or may be made to yield ammonia. The production of calcium carbide involves the use of the electric furnace and hence cannot be carried on economically on a very large scale in Germany owing to the limited water-power available.

(3) Combination of nitrogen and hydrogen at higher temperature and especially under high pressure. The long known fact that the reaction $N_2+3H_2=2NH_3$, is realised to a very small extent at high temperatures has been investigated in recent years by Haber and Le Rossignol at Karlsruhe, and, guided by the principles of modern physical chemistry, Haber has elaborated, after overcoming extraordinary technical difficulties, an industrial process which promises to be of great importance in the future. The most advantageous conditions were found to be :—Pressure 200 atmospheres; temperature, 500° C.; catalytic agent, osmium, uranium, etc.

Production of ammonia by the Haber process has been carried out on a commercial scale by the Badische Anilin Co. since the summer of 1913, and a plant capable of yielding 130,000 tons of sulphate of ammonia per annum was to have been ready during the present year. Inasmuch as the German Colour Syndicates have severed their connection with the Norwegian nitre undertaking, it would appear that they regard the Haber ammonia process as being more likely to be capable of capturing the inorganic nitrogen market of the world.

This synthetic production of ammonia obviously involves cheap hydrogen. I have already referred to electrolytic hydrogen, but there are cheaper sources. Thus water-gas contains theoretically equal volumes of hydrogen and carbon monoxide; the carbon monoxide (b. pt. —192° C.) can be removed by liquefaction from the hydrogen (b. pt. —253° C.). Similarly the nitrogen required for the process is obtainable from the fractional distillation of liquid air. The synthesis of ammonia thus dovetails with the possibilities of cheap low temperature production for which the world is so largely indebted to the German engineer Carl von Linde of Munich.

The German ambition to make their combined nitrogen at home does not stop at the production of synthetic ammonia, for there are still large requirements in respect of nitrates (Germany produces upwards of £1,500,000 of nitric acid annually from Chili saltpetre) which have to be satisfied from foreign sources. They hope, however, to fill this gap in the home-production of combined nitrogen by utilising a reaction discovered by Kuhlmann* as long ago as 1839, in which ammonia and air burn to nitric acid in the presence of platinum as a catalytic agent.

Potash salts.—Germany appears to be alone in possessing vast deposits of potash salts, whilst the enormous value of these to agriculture was first demonstrated by Liebig and made public by him in his "Application of Chemistry to Agriculture and Physiology" in 1840. This work may without question be regarded as the foundation stone on which agricultural chemistry has been raised. The celebrated deposits of potash salts were accidentally discovered in 1857, when boring for rock-salt at Stassfurth, near Magdeburg, in Prussia. Their industrial exploitation on an ever increasing scale was begun in 1861 by Grüneberg and Adolf Frank. In 1861 the production of crude potash salts was 2000 tons; in 1912, 11,000,000 tons, worth £8,800,000. 90% is used as manure (about one-third in Germany itself), and 10% in industries (about two-thirds being worked up in Germany for carbonate, caustic, nitrate, alum, chromate, and chlorate, etc.). America is now experimenting with a view to obtaining potassium chloride from felspar by the method used in the laboratory for determining alkalis in insoluble silicates, and which consists in heating the silicate with a mixture of lime and calcium chloride. Whether it has any commercial future remains to be seen.

This is a matter of prime importance in the United States as potash salts are there used on an enormous scale, especially for agriculture, thus they consumed in 1900 Stassfurth potash salts worth £840,000; in 1910, £2,440,000; and in 1911, £3,040,000.†

Explosives.—I have already mentioned the importance of nitrates and of nitric acid, and have referred to the employment of the greater part in agriculture; of the remainder the major part goes in the manufacture of explosives and in the coal tar colour industry.

Black powder or gunpowder is said to have been discovered by the English monk Roger Bacon (1214-1294). Gun-cotton was discovered by Schönbein in Basle and Christian Böttger in Frankfurt in 1846.

Nitroglycerin was discovered by Sobrero in Pelouze's laboratory in Paris in 1847, and first manufactured on a large scale as an explosive by the Swede Alfred Nobel in 1862.

The disruptive properties of gun-cotton are greatly moderated by gelatinising by means of solvents (acetone, acetic ester, alcohol and ether, etc.), and by mixing with nitroglycerin ballistic materials like cordite, and other smokeless powders are obtained. There is another class of explosives which combine great safety in handling with enormous disruptive effect. Picric acid (discovered by Woulfe of London in 1771), but first used by the French under the name of Melinite for filling shells in 1881, and later by the English under the name of Lyddite. More recently this has been replaced by trinitrotoluene, first proposed by Haeussermann in 1891 for filling shells and used by our Service under the mark "T.N.T." It is even less sensitive to shock than picric acid. "Ammonal," used by the Austrians for shell-filling, is a mixture of T.N.T. with ammonium nitrate, charcoal, and aluminium powder. It is both very safe and very powerful. T.N.T. is much used for demolishing bridges. It is so insensitive to shock that it is not exploded on being struck by a rifle-bullet, and when in a shell it withstands the impact of the latter piercing an armour plate.*

Tetra-nitro-aniline, obtained by Flürscheim, enjoys the unique position among explosives of having been discovered in this country. It is said to be equally safe and even more powerful than trinitrotoluene.

According to the late Oscar Guttmann the production of nitroglycerin explosives in 1909 was as follows:—United States, 20,000; Germany, 10,300; England, 8,100; Transvaal, 8,000; Canada, 5,000; Spain and Portugal, 3,500; Austria-Hungary, 2,300; France, 1,500 tons; Switzerland, Australia, Norway and Sweden, 600 tons each; Russia, Italy, Holland, Belgium, 500 tons each; Greece, 175 tons.

Explosives are of enormous importance also in civil life—in mining and engineering modern explosives have greatly accelerated progress and have rendered possible such works as the Panama Canal. They are also being now employed with great advantage in afforestation for loosening the ground in which trees are to be planted. The manufacture of explosives in Germany is very highly developed. The total German production of 40,000,000 kilos. includes dynamite explosives, 10,000,000; ammonium nitrate explosives, 16,000,000; and black powder, etc., 14,000,000 kilos. There were exported in 1908 value about £1,000,000; and in 1912, £3,000,000.

The world-production of explosives is now about 400,000,000 kilos. or 10 times the German total output. We have at Ardeer, in Scotland, the largest explosives factory (Nobel's) in the world, covering 850 acres, employing 1800 men and 700 women, and producing annually about 16,000 tons of all kinds of high explosives.

Artificial silk.—An eminently peaceful industry which is closely related to that of explosives is the production of artificial silk and celluloid. The manufacture of artificial silk has grown up during the past 25 years, for this product was first shown by Count Hilaire de Chardonnet at the Paris Exhibition of 1889; he discovered the method of its preparation whilst a student in the Ecole Polytechnique at Paris, and in 1891 formed a company at Besançon with a capital of £240,000 for its manufacture.

The chief kinds of artificial silk are:—(1) Nitrated cellulose (soluble in alcohol-ether) silk (denitrated by ammon. sulphide) (Chardonnet silk). (2) Ammoniocupric oxide cellulose silk (Pauly, Fremery, or Urban silk, of the Vereinigte Glanzstofffabrik, Elberfeld, 1897). (3) Viscose-silk (CS_2 in presence of NaOH or $Ca(OH)_2$ on cellulose), (Cross and Bevan). (4) Acetate-silk (acetic acid on cellulose), (Cross and Bevan).

Germany produces about 2,000,000 kilos., value about £1,200,000, exports 600,000 kilos., and imports 1,800,000 kilos.; the imported is principally "alcohol silk," due to disadvantageous alcohol tax in Germany. Germany is the principal user of artificial silk, although the fundamental discoveries upon which the manufacture is based are largely due to French and English chemists.

* Ann. Chem. und Pharm., 1839, 29, 280.
† Molinari.

* Macnab, "Explosives" Inst. of Chem. Lecture, 1914.

The world production is estimated at about 7,000,000 kilos.

The distribution of the industry may be gathered from the following:—France, 7 factories; Germany, 8; Belgium, 3; England, 2; Spain, 1; Austria-Hungary, 4; Russia, 3; America, 3; Japan, 1.

Great profits have been made out of artificial silk (some of the companies have paid 50—100% dividends), and the price has greatly fallen since its introduction from 28s. to 32s. per kilo in 1903, 16s. in 1906, and 12s. (poorer qualities, 6s. to 8s.) in 1910.

The cellulose industries furnish a particularly striking example of the manner in which chemical research and invention are able to enhance the value of the kindly gifts of the earth. Thus, 1 cub. metre of wood has value as fuel about 6s.; (after boiling with lime, soda, and sulphite) as paper pulp, £1 12s.; ditto as paper, £2 16s.; pulp converted into artificial silk, £80 to £240.

Industries dependent on synthetic organic chemistry.—It is out of the profound study of synthetic organic chemistry which has been made during the past 60 years that the industries of artificial dyes, drugs, and perfumes have incidentally arisen. The earlier and pioneering achievements in synthetic organic chemistry are well distributed amongst the nations of Europe,* but during the major part of the 60 years the great bulk of the discoveries in this domain have been made in Germany. Organic chemistry is, perhaps, the branch of science which more perfectly suits the German mind and temperament. It involves the possession of those qualities in which Germans are so pre-eminent—the capacity for taking an infinitude of pains, the capacity to anticipate difficulties and organise means to circumvent them. It is, moreover, only possible to make substantial advances in the problems of organic synthesis if the master has at his disposition a number of highly qualified and docile assistants and apprentices; in a word, the master must be at the head of a large and efficient school of research. It is in the possession of such schools of research, both in the universities and in the chemical factories, that Germany has by two generations the lead of all other countries in the world. Whilst most of the professors of chemistry in our own universities and colleges have under great difficulties and without any sort of encouragement been more or less successful in building up such schools of research, which are, however, by no means slavish imitations of the German model, the chemical manufacturers of this country have, with some notable exceptions, failed to establish anything worthy of the name of research laboratories in connection with their works.

It is in respect of the works research laboratory that there is the greatest contrast between the chemical industries of Germany and those of other countries, and it is not surprising, therefore, that the present war should have served to emphasise the class of chemical products for which we are almost entirely dependent on Germany.† It is precisely those products—artificial dyestuffs, artificial drugs, and artificial perfumes, which are the outcome of the works research laboratories, that are now in many cases unobtainable in consequence of the cutting off of the German sources.

The seriousness of the situation is apparent from the following figures, relating to dyestuffs alone:—The value of dyestuffs consumed in England annually is £2,000,000, and the value of trade in which these dyestuffs are employed is £200,000,000, whilst upwards of 1½ million workmen are dependent upon these industries. The total value of dyestuffs imported into the United Kingdom in 1913 was £1,892,055, of which Germany contributed £1,730,821.

* England and France were, however, more especially to the fore.

† Only about 1/10 of the annual value of dyestuffs consumed in England is produced in our own country.

Perhaps the most concise way of conveying a superficial idea of these industrial products of organic synthesis will be by means of the following classification.

I. Artificial products.—Colours first obtained from aniline by Runge in 1834, by the action of bleaching powder. Aniline colours: Mauve was discovered by Perkin in 1856, and Magenta by Verguin in 1859. Azo-colours* were discovered by Griess in 1859, and introduced on an extended scale in 1878. The azo-colours have achieved an enormous importance and have practically banished cochineal and logwood from the dyeworks. Some 2000 azo-colours in use. Congo-colours, substantive cotton dyes, were discovered by C. Böttiger in 1884.

It must not be supposed that British colour manufacturers have been idle from the days of Perkin; thus in 1880 a very original departure was made by Messrs. Read, Holliday and Sons, who introduced the principle of developing azo-dyestuffs on the fibre with their so-called ingrain or ice colours. Some of these have achieved a great success, thus 2000 tons of *p*-nitraniline are now annually manufactured for the production of nitraniline-red and similar colours.† Again, the discovery of Primulin and the colours which can be derived from it by A. G. Green in 1887, is another very notable achievement.

Eosin colours were discovered by Caro in 1873.

II. Artificially produced natural products.—This group contains substances occurring in nature and long valued by man. The chemical nature of these substances has been carefully ascertained by chemists who have then deliberately set to work to devise methods for their artificial preparation at such a cost as to compete with and ultimately supplant the natural product. These campaigns against the commerce in the products of nature undoubtedly constitute one of the most remarkable phenomena in the history of the world. Bear in mind, it is the production and supply to man of the actual products of nature, but more cheaply than they can be produced and supplied by Nature herself. These endeavours have already been successful on a very large scale.

Alizarin (the essential principle of the madder root) was first synthesised by Graebe and Liebermann in 1869. At the time of this discovery, the world production of madder was 50,000,000 kilos. roots (1—1½% alizarin), representing ½—¾ million kilos. alizarin, value, £2,250,000. In 1870 France had 20,000 hectares (50,000 acres) under madder cultivation, which soon disappeared after the introduction of the artificial product.

The production of artificial alizarin was: 1873, 100,000; 1877, 750,000; 1884, 1,350,000; 1900, 2,000,000 kilos. (four-fifths of this was produced in Germany).

A great number of most valuable artificial dyestuffs, more or less closely related to alizarin, but not occurring in nature, have been prepared by chemists, and the total value of the alizarin-colour exports of Germany at the present time is about £1,000,000.

Indigo.—This most highly prized blue dyestuff of both the ancient and the modern world was first artificially synthesised by Adolf Baeyer in 1880, but it required 17 further years of unremit-

* Both azo and eosin colours were kept as secret products, but the colours were investigated by Hofmann and their mode of production published, to the great consternation of the inventors.

† G. T. Morgan, "Modern Dyes and Dyeing," Roy. Dublin Society, 1914. Cain and J. F. Thorpe, "The Synthetic Dyestuffs and Intermediate Products," 1913.

ting and laborious investigation in the works of the Badische Anilin und Sodafabrik at Ludwigshafen, and the investment of nearly £1,000,000 before laboratory synthesis was translated into a commercially successful industry, for it was in 1897 that the artificial indigo was put on the market.*

In 1896 the world production of plantation indigo (100%) was 6,000,000 kilos., value £4,000,000: four-fifths of this was British, obtained from 1,500,000 acres in British India. In 1904 only 500,000 acres was under cultivation, and in 1913, only 300,000 acres.

	British East Indies.		Germany.	
	Exports.		Imports.	Exports.
	Cwt.	Value, £	£	£
1896	188,337	3,569,670	1,036,000	319,550
1899	135,187	1,980,319	415,450	392,250
1902	89,750	1,234,837	184,350	923,100
1905	49,252	556,405	60,100	1,286,050
1908	32,490	424,819	44,100	1,932,750
1911	16,939	225,000	22,300	2,091,500
1913–14		60,000—70,000		

The price of indigo (100%) in 1897 was 16s. per kilo. and in 1913 7s. per kilo.

By varying the ingredients in the indigo-synthesis, many very valuable dyes related to indigo have been obtained. Thus the chlorine and bromine substituted indigos are manufactured as Ciba-blue, Brilliant-indigo, and Bromo-indigo. Again with sulphur instead of oxygen, Thio-indigo-red, and Thio-indigo-scarlet. Moreover, by using the anthracene-grouping in the indigo-synthesis a number of most important colours have been obtained, *e.g.*, Indanthrenes, of extraordinary fastness to light; Alizarin-indigo; Algol-colours (Rob. E. Schmidt), in all varieties of colour, and of the greatest fastness to light. The discovery of these valuable dyestuffs provoked zealous emulation on the part of the azo-colour chemists, who responded by placing some very excellent new products on the market under the name of Benzolight colours.

Antique or Tyrian Purple was perhaps the most highly prized of all colours in the ancient world. We know from Pliny that this dye was obtained from a rather rare snail living in the Mediterranean, and which he describes under the name of "purpurea." Paul Friedländer, of Darmstadt, succeeded in 1909 in extracting this colour from certain glands of two different species of snail—*Murex brandaris* and *Murex trunculus*—which appeared to correspond to Pliny's description of "purpurea." He removed these glands from 12,000 individual snails, developed the colour by a short exposure to sunlight, extracted it with suitable solvents and recrystallised it from quinoline. In this manner he obtained only 1½ gram. of the colouring matter, so that its extreme costliness, which Friedländer estimates at about £2000 a kilo., is not surprising.

On investigating the chemical nature of this colour he found that it was identical with the already known synthetical compound 6.6′-dibromindigo.

Drugs and perfumes.—Not less remarkable are the achievements of organic synthesis in connection with pharmaceutical and perfumery products.

The production of artificial drugs and perfumes is in general only a branch of the artificial colour industry, for in many cases the raw materials are the same, whilst the methods of investigation and synthesis are of course identical. But whereas the artificial colour industry started in England, that of artificial drugs is entirely of German origin, and may be said to begin with the discovery by Liebig of chloroform in 1831, and of chloral hydrate in 1832. It was in 1869 that the chemical works of Schering, on the suggestion of O. Liebreich, produced chloral hydrate as a commercial article.

In 1887 began the discovery of artificial antipyretic drugs, the rivals of the natural quinine. The first of these was antifebrin, the properties of which were discovered accidentally in consequence of a mistake. A specimen of acetanilide in a Strassburg pharmacy was erroneously supposed to be naphthalene, and was served out as such for some pharmacological experiments by Kahn and Hepp. On being taken, internally, its antifebrile effect was observed. Fortunately there was enough left for analysis, and it was found that the supposed naphthalene was the long known acetanilide, which soon acquired a great vogue for this purpose. About the same time antipyrin was discovered by Knorr, who erroneously thought that it was chemically related to quinine, and that it would, therefore, not improbably possess antifebrile properties. Direct experiment showed that it did actually possess these properties in a high degree, but subsequent research showed that it was in no way chemically related to quinine. These and numerous other artificial antipyretics have been a great source of income to their inventors in consequence of the continued prevalence of influenza during the past quarter of a century.

During the period that antipyrin was protected by patent it was sold at £6 per kilo., whilst on the expiration of the patent the price was reduced to £1 per kilo., which still allows a good margin of profit.

These discoveries have led to the systematic study by direct experiment on animals and human beings of innumerable chemical compounds with a view of ascertaining their physiological properties. The enormous amount of most laborious work which has been carried out in connection with synthetic drugs may be gathered from the fact that up to 1912 about 5000 artificial products had been found to possess therapeutical value of one kind or another, but of course comparatively few of these have permanently established themselves in medical practice. Time does not permit me to do more than refer briefly to some of the simpler and better known synthetic drugs.

Thus of antipyretics, which have or have had some considerable vogue, are: antipyrin; tolypyrin (dimethyltolylpyrazolone); salipyrin (antipyrin-salicylate); antipyrin mandelate (tussol, for whooping cough); neopyrin; pyramidon (three times as strong as antipyrin) (dimethylamino-antipyrin); antifebrin; phenacetin (cheapest antipyretic excepting antifebrin, about 6s. per kilo., and less poisonous than antifebrin); lactophenin, lactyl-*p*-phenetidine; aminophenacetin or phenocoll (also has an antiseptic action).

The above series derived from aniline affords a good illustration of the dependence of physiological properties on chemical constitution. Aniline itself is a powerful antipyretic but is extremely poisonous owing to its ready absorption and action on hæmoglobin. By introducing the acetyl group the toxic properties are much reduced owing to its greater stability, although acetanilide is slowly hydrolysed with liberation of aniline, so that after a time the symptoms of aniline poisoning may supervene. The observation that acetanilide is partially oxidised in the system to *p*-aminophenol led to derivatives of the latter being tried. Thus phenacetin has been found to possess

* Baeyer's first patent for the synthesis of indigo from *o*-nitrocinnamic acid was taken out in 1880, and by 1907 there had been no less than 816 patents obtained in Germany for processes connected with the preparation of indigo.

powerful antipyretic and greatly reduced toxic effects.*

Hypnotics.—Sulphonal was accidentally discovered to possess hypnotic properties in connection with experiments on the transformations of sulphur compounds in the animal system. A dog, which had been dosed with the newly discovered sulphonal, in Baumann's laboratory at Freiburg, i. B., was found to fall into a deep sleep.

More powerful hypnotics were found to result from introducing further ethyl groups :—

$(CH_3)_2C(SO_2.C_2H_5)_2$ Sulphonal

$(CH_3)(C_2H_5)C(SO_2.C_2H_5)_2$ Trional

$(C_2H_5)_2C(SO_2.C_2H_5)_2$ Tetronal.

In connection with the manufacture of sulphonal, I may refer to an interesting difficulty which was experienced by the Elberfeld Colour Works (Bayer und Co.) owing to the appalling smell of the mercaptan from which it is prepared, and of which Emil Fischer and Penzoldt have shown that the human nose is still capable of appreciating 1/400,000,000 mgrm. In spite of this, German thoroughness has been successful in so perfecting the apparatus in which the manufacture is carried on that no nuisance is occasioned.

Veronal (diethylbarbituric acid) (E. Fischer and Mering, patented by Merck in 1903) is one of the most widely used hypnotics. Although it was formerly supposed to be practically free from toxic properties, in recent years cases of veronal poisoning have been known to occur.

Antineuralgics.—Salicylic acid, one of the first drugs to be artificially prepared (Kolbe 1860), acetyl-salicylic acid (aspirin), and salol (phenyl-salicylate), though extremely simple synthetic products, are almost exclusively made in Germany, with the result that their price has now greatly increased. Even synthetic phenol, which is necessary for the above preparations, was exclusively made in Germany and kept down the price of coal-tar phenol. The price of phenol has now enormously increased from 3½d. per lb. to 1s. 4d. per lb., and is likely to go higher. (Pharm. Journal, 1915.)

Anti-gout drugs (Uric acid solvents).—Piperazine (discovered by Hofmann in 1890), lysidine, urotropine (hexamethylene tetramine), atophane (α-phenyl-cinchonic acid).

Suprarenine.—This is of special interest. The active principle of the suprarenal glands known as adrenaline† had for some years been found to be of great value for increasing the blood-pressure, contracting the blood-vessels, and arresting hæmorrhage. It requires the suprarenal glands of 40,000 oxen to prepare 1 kilo. of adrenaline, but this substance has been artificially synthesised by F. Stolz, and is put on the market as suprarenine by the Höchst Colour Works. The synthesis of adrenaline may be represented thus :—

Catechol —($CH_2ClCOCl$)→ Chloraceto-catechol —(CH_3NH_2)→ Methyl-amino-aceto-catechol —(Al-amalgam)→ Adrenaline.

Natural adrenaline is lævo-rotatory; the synthetic can be resolved by tartrate; the lævo is 15 times as potent as the dextro.

The German colour manufacturers are organised into two principal groups or trusts (Interessengemeinschaft). (1) Badische Co., of Ludwigshafen; Bayer Co., of Elberfeld; Berlin Aniline Co. (2) Cassella Co., of Frankfurt; Meister, Lucius, und Brüning, of Höchst.‡

The share-capital of the above two groups in 1911 was £8,000,000, paying a dividend of 25·8%, and probably now about £12,000,000, dividend, 28%.

* "Chemistry of Synthetic Drugs," P. May, 1911.
† Discovered by Takamine in 1901.
‡ "German Coal Tar Companies," Textile Mercury, Jan. 9, 1915.

In 1860–70, Germany imported about £2,500,000 worth of dyes per annum, while in 1912, Germany exported about £10,000,000 and produced about £12,500,000 of dyes.

The composition of the personnel who carry on these German colour works is at the bottom of their success. Take the Works of Messrs. Meister, Lucius, und Brüning as an example. In 1913 the composition was as follows:—Workmen, 7680; managers, 374; expert chemists, 307; technologists, 74; commercial staff, 611. Contrast with the above the fact that the six English factories now producing dyestuffs employ altogether only 35 chemists, whilst evidence of their relative activities is again furnished by the circumstance that between 1886 and 1900 the English firms took out only 86 patents, whereas the six principal German firms were responsible for 948 during the same period.

Having shown that these German coal-tar colour manufacturers are without rivals from the commercial point of view, I feel it to be my duty to point out also that their industry is carried on under conditions of labour which are highly creditable to the management.

This vast and highly organised industry of dyestuffs and fine chemicals, which is certainly one of the most outstanding manifestations of the modern German spirit, was formerly very dependent on England for its chief raw material, coal-tar, and it is interesting to see how effectually Germany has emancipated herself from a control which might at any time become irksome or even paralysing.

German coal-tar production.

	Coke ovens.	Gas manufacture.
	tons.	tons.
1897	52,000	
1900	93,000	
1904	277,000	225,000
1908	632,400	300,000

In 1908, 40,000 tons was still imported from England, and in 1909, 18,000 tons, but 35,000 was also exported.

In 1900 the German production of coal tar was only about one-half of that produced in England, whilst by 1912 it had equalled if not surpassed the English production. Again, in 1880, Germany used 1400 tons of pure anthracene, of which only 200 tons was of German origin, whilst at the present time the 5000 tons now employed in Germany is all produced there.

The phenomenal increase in the German coal tar production has depended on a similarly rapid development of the German iron and steel industry, which has entailed an enormous demand for metallurgical coke in the production of which the greatest attention has been devoted by Germany to the recovery of the by-products—tar, gas, ammonia, etc.

In England the quantity of coal-tar treated was 175,000 tons in 1870, and 640,000 tons in 1880; at present over 750,000 tons is treated.

With regard to the synthetic perfume industry, the facts are in many respects essentially similar to those in connection with the artificial dyestuffs. The production of artificial perfumes, in many cases the identical substances which are produced by nature, has assumed very large proportions in Germany, the annual output being estimated at about £2,500,000. It is again particularly noteworthy that one of the first steps in the realisation of this remarkable achievement of artificially building up the natural perfumes was also made by William Henry Perkin, who in 1868 succeeded in synthesising coumarin, the highly valued odoriferous principle of the woodruff (*Asperula odorata*).

The effect of artificial synthesis on the price of natural perfumes may be gathered from the following examples :—

	Price of 1 kilo.	
	Natural.	Synthetic.
Coumarin	£25	£1 5 0
Vanillin	£50	£1 10 0
Heliotropin	£150	10 0

The facts which I have brought forward speak for themselves and proclaim in the most convincing manner the stupendous progress which has been made by Germany in the chemical industries during the past 40 years. It is equally certain that England, once pre-eminent for chemical manufactures, has not progressed at the same rate and is at the present moment suffering much inconvenience through being so largely dependent on German chemical products of one kind and another. The country is now reaping the harvest of humiliation which it has sown for itself in spite of the warnings repeated *ad nauseam* by the chemical profession during a whole generation. The systematic neglect of chemical science and the failure by manufacturers to utilise the services of highly qualified chemists, could only lead to the result that all the industries which are dependent on a profound knowledge of chemistry should tend to disappear from our midst and pass into the hands of those who are prepared, not only to apply new chemical discoveries to industry, but even to prosecute the most varied chemical investigations in the hope of sooner or later making discoveries which shall be of advantage to their commercial undertakings. The mischief caused through the neglect of chemistry by practical men in this country has been so subtle that to a large extent it has remained concealed from the average man of intelligence and from the governmental classes. During the past 40 years our country has been accumulating wealth in an altogether unprecedented fashion, so that the loss or restriction of some industries appeared a matter of unimportance to political observers taking only a broad and superficial survey of the national resources. The whole of our arrangements have evolved during the past half century on the assumption that this country would never again be engaged in a European war, whilst still more recently the new democracy has vainly boasted that it could prevent such a war by means of a general strike. The year 1914 has seen the dissolution of many fool's paradises and has given the *coup de grace* to all these vain imaginings, with the result that we find our vast textile industry in serious peril because the much smaller dyestuff industry has been complacently allowed to slide into the hands of our sagacious and more painstaking enemies. The same carelessness and want of foresight had even allowed us to become dependent on Germany for some of the most important materials used as explosives, *e.g.* trinitrotoluene, and for many of the most valued drugs required alike by our Army, Navy, and civil population.

The complete breakdown in our supply of fine chemicals, which is the direct outcome of the disregard of the constant warnings emitted by scores of British chemists, has led the Government of the day to intervene and attempt to remedy the intolerable state of affairs which has arisen in connection with the supply of coal-tar colours.

We devoutly hope that success will attend the endeavour to establish the coal-tar colour industry in these Islands on the largest possible scale. Whatever the ultimate scheme adopted may be, I would venture to point out that it must be based on a clear understanding of the following considerations :— 1. That the provision of the required chemicals during the continuance of the war is one thing, and that their production on a commercial basis after the cessation of hostilities is quite another matter. 2. It appears to me that in order to provide the needful supply during the war, the only reasonable course is to assist in every possible way those firms which are already making similar or closely allied products so as to enable them to produce their present goods on a larger scale, and as far as practicable to undertake the manufacture of others which are urgently required. The immediate problem will be also greatly facilitated by utilising supplies obtainable from neutral powers, and more especially from Switzerland, which is the only country, other than Germany, in which the manufacture of dyestuffs and similar chemical products has been vigorously prosecuted. As a matter of fact, Mr. Runciman admitted in the House a short time ago that the Government had granted licences to trade with the enemy in the matter of dyestuffs ! 3. As regards the prospects of the home industry after the war, it will require " nursing." I use the term advisedly in order to obviate the employment of another and much more familiar one which is so dear to some politicians and so hated by others ; it will require nursing for a much longer period of time than has hitherto been mentioned. In this connection I would point out that the sum of £10,000 a year for 10 years, which it has been proposed to guarantee for research purposes, is absurdly inadequate. 4. If the industry is to prosper it will not only have to manufacture materials already known, but also continually to be introducing new products of its own discovery, as well as constantly to be seeking to produce more economically a great number of auxiliary chemicals required in the manufacturing processes. It is also essential that the undertaking should branch out into the manufacture of other materials as occasion may arise for advantageously utilising by-products. 5. The competition which the industry will have to suffer from Germany is likely to be much more serious than is generally supposed, because it must be remembered that England only takes, as we have seen, about one-fifth of the total German exports of dyestuffs, so that it would be comparatively easy for German firms specially to reduce the price of the goods sent to England. They have already done this in America when attempts have been made to start an aniline industry there. It is particularly significant, and augurs ill for the prospects of this scheme to rehabilitate the coal-tar colour industry, that the latter has failed to flourish anywhere excepting on German soil, and that countries with fiscal systems entirely different from our own have been no more successful in this respect than have we ourselves. 6. It will certainly be necessary that expert chemical knowledge should in the future be much more highly remunerated than it has been in the past, otherwise the supply of able and properly qualified men will not be forthcoming. The flow of men of high grade intelligence into a profession is determined by the prizes which the profession has to offer, in the form of money and social position. Consider the great stream of able men who are attracted to the English Bar, in which profession the prizes, although limited in number, are of the most substantial kind, with the result that the successful leaders are selected by the fiercest competition in a very wide field.

If there is to be a large influx of high intelligence into the chemical profession, it will be necessary that there should be some very different prizes from the paltry bait which is offered at the present time, for the study of chemistry in this country now only draws those men who either have or think they have an overpowering zeal and passion for the science, to which they devote themselves against the advice of their friends, and in spite of the warnings of the professors of chemistry by whom they are initiated. Notwithstanding the absence of material inducements, I venture to say without fear of contradiction that there is more original investigation being prosecuted in this country by chemists than by any other body of British men of science, and this I attribute to the fact that such a large proportion of our number have either been at German Universities or are the pupils of those who have been at these centres of research. Nor are any of us, I am sure, even during this unfortunate crisis, unmindful of the hospitality and the inspiration which we have received in the schools of the enemy. 7. If the proposed undertaking is to succeed, real chemists must be on the directorate, and in a sufficient proportion to give effect to their views. Many men of science are excellent business men. What does experience teach in the case of flourishing chemical industries which we fortunately still have amongst us? What does not the firm of Messrs. Brunner, Mond and Co., for example, owe to the late Dr. Ludwig Mond, F.R.S.? 8. In attempting to establish a commercially successful coal tar colour company on a large scale in this country, I venture to think that the Government have undertaken a task which they will find to be surrounded with difficulties of quite a different order from those which they have had to encounter in some of their most striking previous legislative acts, such as the provision of salaries for members of Parliament, the granting of Old Age Pensions, and the establishment of a compulsory system of Insurance. These are matters in which if the Government dictate we are obliged to obey, but the commercial success of an industry which is based upon progressive scientific investigation depends upon factors so subtle and elusive that they cannot be coerced even by a majority of the House of Commons. 9. If the chemical industries are to be rehabilitated in this country, there must be a complete change in the attitude of mind towards science in general, and towards chemical science in particular, amongst the influential classes of the population, and it will certainly not be effected by following the precept "business as usual," but by pursuing a policy which is the exact opposite of what is implied by that vulgar and undignified phrase.

London Section.

Meeting held at Burlington House on Monday, February 1st, 1915.

MR. W. F. REID IN THE CHAIR.

Mr. J. J. EASTICK moved the following resolution:—

"That in the opinion of this Meeting representing the London Section of the Society of Chemical Industry, the Council of the Society should petition the Government to take such steps as will tend to the permanent production and refining within the Empire of sugar sufficient for the Empire's consumption."

He said that he was firmly convinced that with a trade to be captured equal to £18,000,000 sterling there was ample room for both beet and cane, and for all their Colonies.

Unfortunately in the past no united efforts of an Imperial nature had been made to formulate a comprehensive scheme that would serve the interests of the whole Empire. That was now necessary if supplies of sugar at a normal price to the consumer were to be secured. The present cost was equivalent to an enormous tax on the consumer and the manufacturer. Sugar was the only food in which the British working-classes were being penalised more than their enemies. They had become dependent upon Germany and Austria for a million and a quarter tons of sugar every year. That was the bulk of their supplies. The Board of Trade returns showed that 80% of their sugar was beet-grown sugar from the Continent, and only 20% represented cane, a very small proportion of which 20% was from the colonies.

In competing with the enemy's trade or industry, in many cases they were handicapped by patents, but in the sugar industry they lacked nothing. Their engineers, both English and Scotch, made the most substantial sugar machinery in the world. Their agriculturists had made successful experiments in cultivating sugar-beets. Their cane-fields only required permanent conditions to expand rapidly. Every civilised nation with a suitable climate, except Turkey and Persia, had succeeded in providing for the bulk of their sugar supplies within their own borders, and why should not the British Empire do likewise? They had to look forward at once for supplies. Even if they were in peaceful communication with the Continent in a few months, it would be a long time before the beet industry could get in full working order. The factories in Belgium, France, and Russian Poland were practically demolished. There were a few isolated cases where they were working, but it would be a long time before normal days came again.

He thoroughly and firmly believed in the desirability and feasibility of producing their own beet sugar in England at a profit. No excise duty had yet been levied on sugar, although the Anglo-Netherlands Company had been in operation three years.

Captain COURTHOPE, M.P., in seconding the Resolution, said that he cordially agreed there was plenty of room in the British Empire for both beet and cane. The United Kingdom consumption of beet sugar alone represented a value of roughly some £20,000,000, or upwards, per annum, and it was the product of over a million acres of land each year. The Cantley factory was built about three years ago by an English company entitled the Anglo-Netherlands Sugar Corporation, and was financed very largely from the Continent. They had had three years of uphill work, in contending with unforeseen difficulties, but he hoped they were on the way to the establishment of the industry and ultimate prosperity.

They had had also to overcome the reluctance of the farmer to start a new crop. It was particularly important from the farmer's point of view that the beet industry should be established. If the beet industry were established here, it would unquestionably have the effect of largely increasing their production of white straw crops, and the arable acreage. The arable farmer had to work out his profit and loss account, not on a single crop of a single year, but over four years of his rotation, or whatever the period was. There was hardly a case where wheat, by itself, if it was ever brought to harvest at all, did not show a profit; but there were thousands of cases in which the profit on the wheat, oats, or barley was so small that it was swamped or more than swamped