

trajectory is kept within narrow limits. Mathematical investigation shows that the point of the projectile moves in cycloidal curves.

In the projectile, as in the top, this "precessional" movement of the axis is inversely proportional to the velocity of rotation about the axis. This fact must be considered in connection with the problem of rifling. Too rapid rotation, caused by too large an angle of rifling, may in some conditions make the precession too slow

to correct deviations of the axis from the trajectory. The difficulties are increased when the gun is designed for use at widely different elevations. It is evident that no sort of rifling can invert at the summit of its flight a projectile which is fired vertically upward, or can prevent such a projectile striking the ground with its base, instead of its point. Hence, in testing a given rifling, the gun is progressively elevated until the projectile strikes in this manner. The elevation thus determined, the

elevation at and beyond which the rifling fails, depends upon the angle of rifling at the muzzle, the caliber and the velocity of the projectile. Regarded from this viewpoint, the new German 42-centimeter mortar represents a far higher technical achievement than appears at first glance. The great increase in caliber is not only a matter of improvement in the use of materials and in methods of construction. It also involves new calculations, based upon many long and costly experiments.

## The Dyestuff Situation\*

### Reasons Why the Establishment of Competative Plants Would Be Poor Financial Policy

By Arthur D. Little

MANUFACTURERS of American flags are in no immediate danger of having to rely upon Cape Cod cranberries for their red or California skies for their blue. Nor is it probable that our textile manufacturers generally will be forced to adopt the suggestion that we utilize our native rainbows to supply the tinctorial requirements of their industry. Six months ago the situation was different. You could have sold rainbows by the foot. The people generally and even the consumers of dyestuffs awoke at the first declaration of war to the long patent fact that the industries of these United States are dependent upon Germany for their supplies of coloring matters, synthetic drugs and many other highly necessary products derived from coal tar. A situation which had been eminently satisfactory to consumers for many years suddenly appeared humiliating and intolerable when the embargo first threatened to cut off supplies. There were insistent demands for the immediate inauguration of an American coal-tar color industry to relieve the situation and render impossible its recurrence. It was to be established by changing the tariff and the patent laws and letting somebody else find the money. Government ownership of dyestuff plants was not considered seriously because there were no German plants interned.

With the lifting of the embargo and the resumption of shipments by way of Rotterdam most of the humiliation disappeared, while now there is even a growing disinclination upon the part of textile manufacturers to let the other fellow find the money—and make those essential changes in the tariff. The situation nevertheless remains one to cause concern and involves many factors which are worthy of your serious consideration.

All the world knows that during the last 50 years a sweeping revolution has been effected in the art of dyeing. The vegetable dyes like logwood, fustic, sumac, madder, indigo and many others, the few animal dyes like cochineal and the relatively crude mineral pigments have all been displaced completely or in greater part by the products of synthetic chemistry after a record of tinctorial service extending back to the days of Genesis. The coal-tar color industry, which began in 1856 with the discovery of mauve by an English boy of eighteen, known later as Sir William Henry Perkin, soon took root in Germany where it has attained its present great development and delicately adjusted organization mainly through the genius of a few and the plodding industry of many German chemists, the far-sighted courage of German financiers and the technical and business sagacity of German managers. It is in a very real sense a created industry brought into being by the reaction of intellect upon the black chaos of coal tar. It is peculiarly a German industry and its products for the most part may justly and proudly bear the legend, "Made in Germany."

Contrary to popular belief the products of this industry have displaced the old vegetable dyes because they are better, brighter, faster, easier of application, cheaper and incomparably wider in color range.

With our textile and paper mills, paint and varnish manufacturers, makers of printing inks, and many minor industries thus definitely committed to the use of coal-tar dyes it is not surprising that the sudden prospect of a dyestuff famine should have occasioned grave concern. At the outbreak of the war the textile mills were generally credited with having not more than five months' supply on hand. The other industries concerned were probably less fortunate. For a time the German embargo on dyestuffs prevented shipments, and stocks were rapidly depleted. Through the persistent, earnest and capable efforts of American representatives of the German manufacturers shipments have been resumed under some restrictions but with reasonable regularity. The German plants are running at about 60 per cent capacity and distribution of their product is regulated by the Government through the Society of Dyestuff Manufacturers. The basis of allotment is said to be 75 per cent of the 1913 consumption dis-

tributed over monthly shipments which must go forward in American boats. There is little doubt that to prevent re-shipment to the allies it is the German policy to keep our own mills in a chronic state of dyestuff hunger. As a result many mills are now running from hand to mouth, others claim to be provided for three months and a few for a somewhat longer period on certain lines of colors.

As a result of the close interdependence of the coal-tar dyes and coal-tar explosives industries there has been a practically complete cessation of receipts of such dyes and developers as require for their manufacture nitric acid or raw materials derived from coal tar and available for the production of explosives. Such materials for example are toluol and carbolie acid.

The acid blues and acid blacks largely used in dyeing woollens are already scarce as are also most yellows and oranges and a wide variety of blues and greens. Paranitraniline, used in connection with pigment red poster work, is practically out of the market and it may be said that pigment workers generally find themselves in an especially precarious condition as to dyes.

Nitro developers are cut off entirely and beta-naphthol is obtainable only at prices which are almost prohibitive. Within a fortnight a large gingham mill has purchased 1,200 pounds at \$1.50 a pound, as against a normal price of 9 to 9½ cents.

In this connection it is only just to point out that the German manufacturers and the agents and importers here have handled the difficult and abnormal situation created by the war in a spirit of great fairness. They have prevented stocking up by greedy consumers, they have apportioned supplies impartially on the basis of past consumption, and they have shown remarkable restraint in the matter of prices. The present average advance on obtainable colors is about 25 per cent based on a 10 per cent increase in factory price and higher insurance and freights. In some cases the advance is 35 to 40 per cent. There is every prospect that with the diminution in the supply of raw materials prices will go much higher in the near future. There is a compensating, though somewhat remote, possibility that the manufacture of nitro dyes and developers may be resumed as the German government has subsidized the construction of two large plants for the manufacture of nitric acid from the air and these are expected to come into operation during the present month.

In the face of the present emergency the textile mills are resorting wherever possible to the old vegetable dyes and are already making free use of logwood and fustic. As a result these woods and their extracts have experienced a marked advance, amounting in case of fustic to 100 per cent. Paper mills are endeavoring to confine their product to natural and white papers or those which are tinted rather than deeply colored and all consumers are husbanding their color resources with the utmost care and adopting makeshifts wherever possible. It is gratifying to note that in these efforts they have the cordial and effective co-operation of the laboratories and technical staffs of the great importing agents.

In 1913 the average dividend paid by German dyestuff factories was 21.74 per cent. The actual earnings were much greater, and have sufficed in the past to provide sinking funds to cover the entire costs of development and plant. Few industries in the United States can make so good a showing. It seems reasonable, therefore, to inquire why we should endure indefinitely the present hardships and why we should not have a coal-tar color industry of our own which should supply our wants without let or hindrance from Germany. There is but one answer to these questions and but one consideration to restrain us. We can have such an industry whenever we are prepared to pay the price but is it worth that price?

The coal-tar color and explosives industry as developed by Germany is probably the most highly organized of any industry in the world. Starting with less than a dozen crude raw materials such as benzol, toluol, anthracene, naphthalene, carbolie acid, etc., derived from coal tar, it builds up by complex chemical processes

which often involve elaborate and expensive plants and the most rigid scientific control of operating conditions more than nine hundred separate ultimate products and over three hundred intermediates, so called, or over twelve hundred products in all, some of which cannot be turned out commercially in quantities much over 100 pounds. The whole system of production depends for its commercial efficiency upon the close correlation and interdependence of these many products. The industry is self-contained. It makes its own crudes and converts its own wastes into raw materials for new processes to be applied to them by itself. The adjustment of the economic balance is so close that a slight change in the value of some one product may disarrange whole series of processes and affect disastrously many products. Obviously, therefore, at this stage of its development, the industry must be considered as a whole if any effective competitive development in this country is to be attained. The situation is not unlike that now existing in our packing industry, where, by rougher methods indeed, but on a far greater scale, the entire raw material is utilized in a complex series of related products which are individually profitable only because of their relations to the others.

Twenty-two factories are involved in the German dyestuff industry but by far the larger portion of the business is in the hands of four great companies. The industry as a whole is bound together by trade agreements and co-operative arrangements which add greatly to the efficiency of production.

A few figures regarding one of these companies are instructive. For transportation within the plant it utilizes 42 miles of railroad. Its water works supply 10 billion gallons yearly and its ice factory 12,000 tons of ice. It has 400 steam engines, 500 electric motors, nearly as many telephone stations, and 25 steam fire engines. It has a frontage on the Rhine of 1½ miles and handles sulphuric acid in tank steamers. Seven years ago it employed 217 chemists, 142 civil engineers, 8,000 workmen, and a commercial staff of 918. Perhaps even more important from the present point of view of the American business man is this significant statement published by this company:

"On looking back upon the successes which the Badische Anilin und Soda Fabrik has achieved since its foundation the management feels it to be their pleasant duty to remember gratefully the benevolent and appreciative support which their efforts have always met at the hands of the State authorities."

Within the last few weeks, Dr. B. C. Hesse, of New York, who combines in a remarkable manner the functions of the chemist and statistician, has brought together many figures which bear upon our present problem and which give some indication of the price which we would have to pay for an American coal-tar color industry.

The world's production of all coal-tar dyes is substantially \$100,000,000. The annual turnover of the German plants is about \$80,000,000; the plant value on various estimates is not far from \$400,000,000. It will be noted that the relation of plant investment to output is extremely high, being \$5 to \$1. There is one works chemist to every \$80,000 of output and about 50,000 employees in all. The total export value of the German product was about \$55,000,000, which was distributed among 33 countries. China takes four times as much German indigo as the United States consumes. The average wage in the industry was 4.80 marks inclusive of boys, common labor and skilled labor. The average men's wage was 5.85 marks, or \$1.40, which is brought by bonuses and social service to the equivalent of \$1.84. The gross average export value of the 1912 dyes produced is \$61,405 each, or, excepting a very few of the most important, the corresponding figure for the remaining 900 or more is \$40,811. Dr. Hesse has characterized the German coal-tar color industry as "just about a one-nation business," and on this showing I would ask you if Dr. Hesse is not right.

It is nevertheless an industry which has been replete with romance and with great achievement. The syn-

\*Address before the United States Chamber of Commerce, Washington, February 5th, 1915.

thesis of alizarine for example, gave a death blow to the cultivation of madder, the annual production of which 45 years ago was about 500,000 tons. Synthetic indigo upset the social economy of whole regions in India, and made available for raising food great tracts of land before devoted to the cultivation of natural indigo. These triumphs of organic chemistry unquestionably reacted throughout the entire range of German industry and did much to convert the nation to the cult of science upon which its extraordinary efficiency in material affairs is based. These considerations, coupled with the industrial miracle of the genesis of the rainbow from so unpromising a material as coal tar, enable the coal-tar color industry to make a peculiarly powerful appeal to the imagination. We would be justly proud had we developed it ourselves.

We have in a sense had a coal-tar color industry in this country for 30 years but it has failed to take deep root or flourish even under the protection of a 30 per cent tariff, and during the very period when the German industry, under the far greater stimulus of organized and persistent research, achieved its greatest technical and commercial triumphs. There are to-day four plants in the country and they make perhaps 15 per cent of the total American consumption but confine themselves to less than 100 products. They hold out no promise of extension increase in production without Government assistance to the extent of a 30 per cent *ad valorem* duty plus  $7\frac{1}{2}$  cents per pound specific and an effective anti-dumping clause. In this connection it might be pointed out that from 1880 to 1883 the *ad valorem* duty was 35 per cent with 50 cents specific. The present duty is 30 per cent on colors and 10 per cent on intermediates, with synthetic indigo and alizarine colors free. Under it, probably not more than 17 of the 912 German dyes are completely fabricated in this country; the remaining 83 of the 100 types claimed as American products are merely developed or "assembled" here from intermediates obtained from Germany. Were our own manufacturers to secure the entire American business it would amount to only about \$10,000,000 annually—a little more than the value of the candy sold by the Woolworth stores.

Since the United States now produces 125,000,000 gallons of coal tar annually it may here be pointed out that the country already possesses a coal-tar industry as distinguished from a coal-tar color and explosives

industry, and that the coal-tar industry as such has been developed here to an extent unthought of in Germany. An average tar yields 70 per cent of pitch and only 6 per cent of materials useful to the color industry. In Europe the pitch is commonly used for fuel. In the United States upon the other hand over 90 per cent of the pitch is utilized in roofing, waterproofing and road-making, while the creosote oil and naphthalene find other profitable and well known applications.

The plain underlying reason why we have been unable during 30 years of tariff protection to develop in this country an independent and self-contained coal-tar color industry while during the same period the Germans have magnificently succeeded is to be found in the failure of our manufacturers and capitalists to realize the creative power and earning capacity of industrial research. This power and this capacity have been recognized by Germany and on them as corner-stones her industries are based. As a result the German color plants are now quite capable of meeting the demands of the whole world when peace is once restored. Why, then, should we duplicate them only to plunge into an industrial warfare against the most strongly fortified industrial position in the world. Let us rather console ourselves with a few reflections and then see how otherwise we might spend our money to our better advantage.

The gross business of the Woolworth 5 and 10 cent stores in 1913 exceeded the entire export business of the whole German coal-tar color industry by \$11,000,000. The sales of one mail order house, Sears, Roebuck & Co., in the same year were far greater than the total output of all these German color plants, and its last special dividend is about twice the amount of their total dividend payment in 1913. The Eastman Kodak Company, with about twice the capital of the largest German color company, the Badische, and with a Government suit on its hands, earned during 1913 net profits of over \$14,000,000, or 230 per cent on its preferred stock and over 70 per cent on its common, while the Badische with "the benevolent and appreciative support" of the German government earned 45 per cent. In that year the entire German industry paid \$11,000,000 in dividends. The Ford Motor Company with one standardized product does a greater annual business than all the German color plants with their 1,200 products and earns four times their combined dividend while paying three times their wages.

Now that our perspective is adjusted let us consider for a moment some of the things which might be done with the vast expenditure of effort, money and research required to establish in this country this "one-nation" industry.

We should first of all review our own almost boundless natural resources and especially should we consider our gigantic and shameful wastes. They offer opportunity for the ultimate development of a score of industries, each of a magnitude comparable to the color industry of Germany, and for the almost immediate upbuilding of hundreds of smaller enterprises relatively no less profitable. We waste for instance, 150,000,000 tons of wood a year, a billion feet of natural gas a day, millions of tons of flax straw at every harvest, untouched peat deposits fringe our entire Atlantic seaboard, beehive coke ovens flame for miles in Pennsylvania, wasting precious ammonia and exciting no comment while the burning of a \$1,000 house would draw a mob. The whole south is a reservoir of industrial wealth untapped in any proper sense. We have heard these things so often that we can go to sleep while hearing them. We need to really sense them, to get before our consciousness a clear conception of what they actually mean in terms of wasted wealth and present opportunity. When we do this, and there is no better time than now, let us apply the lesson of the German coal-tar color industry to these far greater problems and solve them by the compelling agency of sustained, intensive research.

To take one illustration only, the application to the lumber industry of the south of one tenth the research energy and skill which were required to bring the coal-tar chemical industries to their present proud pre-eminence would unquestionably result in the creation of a whole series of great interlocking industries, each more profitable than that of lumbering. The south would be in position to dominate the paper market of the world, it would transport denatured alcohol by pipe line and tank steamer, make thousands of tons a day of carbohydrate cattle feeds, reorganize and develop along new lines and to far better purpose its languishing naval stores industry, and find new opportunity at every hand. To do these things in one industry as well as many things as good in other industries requires generally only a little faith, sustained, courageous effort, and the appreciation by American financiers of the earning power of research.

### Arthur Von Auwers\*

THE problems that confront the astronomer differ from those with which workers in other departments of science are engaged in many important particulars, but in none more than in the magnitude of the data involved. So great is the number of the stars, so vast, both in space and in time, the scale of their motions, that in general it transcends the powers of an individual, or even of a single observatory; to collect, within the span of a lifetime, the materials for comprehensive studies, or to collate and discuss them. Co-operation is probably more essential to progress in astronomy than in any other science.

The earliest example of co-operation on a large scale in astronomical research was the proposition brought forward by Argelander and his associates, half a century ago, for the formation of a great catalogue of all the stars to the ninth magnitude in the northern sky. At the meeting of the Astronomische Gesellschaft in 1869, when, after four years of preliminary discussion, the project was formally initiated, the plan of work adopted was the one presented by Dr. Arthur Auwers, a young astronomer, who, three years earlier, had been elected to membership in the Berlin Academy of Sciences to fill the place left vacant by the death of Encke. In view of Auwers's youth—he was then only thirty-one—this was a notable recognition of his ability. But even more significant was the fact that to him was also entrusted the all-important duty of preparing the system of fundamental star places which provided the foundation for the entire work.

It is impossible, without running unduly into technicalities, to give an adequate idea of the difficulties attending the construction of such a fundamental system of star places. It must suffice to say that it requires the highest order of ability, a profound grasp of the principles of gravitational astronomy, a comprehensive knowledge of star catalogues, rare judgment, and a mastery of detail that is given to but few minds. How well qualified Auwers was for the responsibility placed upon him is evident from the fact that the fundamental system he elaborated more than forty years ago is adopted, in all its essentials, as the foundation of the greater part of the most refined meridian circle work of the present day.

His connection with the "Astronomische Gesellschaft Catalogue" did not end with the service I have described. In addition, he undertook the observation of

one of the sections or "zones" of the catalogue, producing a model work, and was soon made chairman of the commission in charge of the entire project, a position he held to the date of his death, January 24th, 1915. Its success, therefore, is in large measure due to his careful planning and wise guidance. Long before his death he had the satisfaction of seeing the original catalogue completed by contributions from no less than twelve great observatories in Europe and America, and of having the plan extended, again under his direction, well into the southern hemisphere.

G. F. J. Arthur Auwers was born in Göttingen in 1838 and received his early education in the schools of his native city. His interest in astronomy was manifested when he was still a mere boy, and even before he received his doctor's degree at Königsberg in 1862, he had made many important contributions to it both by observations and by theoretical investigations. His dissertation for the doctorate, on the variable proper motion of Procyon, placed him at once in the front rank of astronomers. In this research he struck the keynote of his future life-work, "the treatment of all questions concerning the positions and motions of the stars."

The fundamental data upon which all studies of the mechanics of the stellar universe depend are the positions of the stars on the celestial sphere, their apparent motions on this sphere (technically, their "proper motions"), their radial velocities, and their distances. The first two of these elements are derived from the star catalogues based on meridian observations. One of the most important of all star catalogues is that based upon the observations of Bradley, at Greenwich, about the middle of the eighteenth century, for these observations were the first that are at all comparable in system and in accuracy with those of modern times, and they were also superior to those of his successors for fully half a century. As the time element is of the first consequence in the derivation of stellar proper motions, Bessel, who in 1819 made the first reduction of the Bradley observations, was fully justified in giving his work the title "Fundamenta Astronomiæ." Excellent as Bessel's work was, the rapid progress of astronomy in the next half century led to a more accurate knowledge of the fundamental astronomical constants and to more refined methods in the reduction of meridian observations, and it also became evident that some of his assumptions respecting Bradley's instrument were erroneous. A new reduction was therefore highly desirable and this was undertaken by Dr. Auwers in 1866. He

brought all his skill and special knowledge into play and spared no pains to insure the utmost accuracy in his work. The result of the ten years' labor it involved has been well called a "masterpiece and a model." The Auwers-Bradley catalogue at once became the starting point for all discussions of proper motions, a position it will probably hold for all time.

His fundamental system of star places, the Auwers-Bradley catalogue, and his other work in related fields, will form Auwers's most enduring monuments, but they are far from comprising the full measure of his activities. Thus, he was chairman of the German Commission for the determination of the solar parallax from the transits of Venus in 1874 and in 1882. He took the leading part in preparing the observing programmes, conducted in each year one of the expeditions sent out by the government, and personally directed the elaborate discussion of all the results—a truly monumental work which fills six large quarto volumes.

From 1878 to 1912 Auwers held the position of secretary of the Section for Mathematics and Physics in the Royal Prussian Academy of Sciences (Berlin Academy) and his tactful conduct of the manifold duties of this office, together with his unselfish and tireless devotion to the interests of the academy, were gratefully acknowledged by his colleagues at the meeting of June 25th, 1912, when they celebrated his jubilee—the fiftieth anniversary of his graduation as doctor of philosophy.

He founded the bureau of the "History of the Sidereal Heavens" (Geschichte des Fixsternhimmels), whose object it is to collect all of the meridian observations of stars since Bradley's time and to combine them into a single systematic catalogue. He was a member of the commission charged with the organization of the Astrophysical Observatory at Potsdam, and assisted in the supervision of its construction and of its management in its early years. He was also the first president of the International Association of Academies.

Auwers's commanding position in his chosen science was fully recognized in his own country and throughout the world. His own government gave him the title Wirklicher Geheimer Ober-Regierungsrat, and at the time of his death he was Kanzler des Ordens pour le mérite für Wissenschaft und Künste. For more than twenty years before his death he had been a member of the seven leading National Academies of Science in Europe and America, a distinction in which but two other astronomers of his generation shared—Newcomb and Schiaparelli.

\* R. G. Aitken in Science.