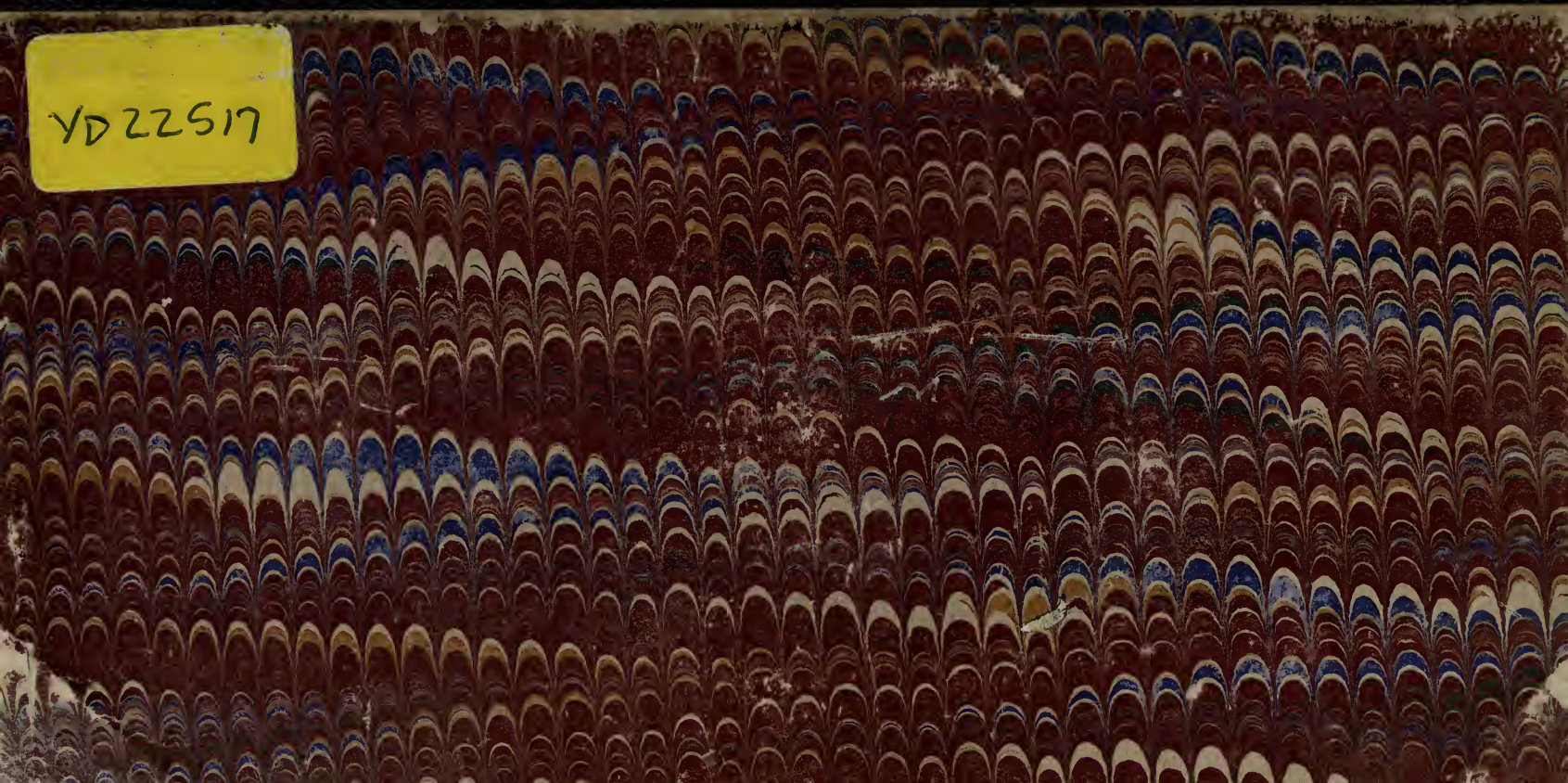

THE ADVANTAGES

—OF—

EDUCATED LABOR

IN MISSOURI,

By S. WATERHOUSE.

A Lecture delivered at Washington University,
April 26th, 1872.

EDITION—10,000 COPIES.

ST. LOUIS:
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PREFACE.

THE following lecture on "SKILLED LABOR" is published in compliance with the accompanying request of the St. Louis Board of Trade, the recollection of whose personal courtesies will be gratefully cherished by the author of these pages.

OFFICE ST. LOUIS BOARD OF TRADE, April 30th, 1872.

PROFESSOR S. WATERHOUSE, *Washington University:*

DEAR SIR: I enclose herewith the resolutions passed by this Board at its meeting on the 29th inst., and trust that you will accede to this request, and furnish for publication a copy of your very able and interesting address on "Skilled Labor."

I was individually deeply interested in the facts it contains, and believe much good will result from giving it a wide circulation at home and abroad.

With assurances of my very high personal regard and also that of the Board over which I have the honor to preside,

I am your friend and obedient servant,

B. R. BONNER, PRESIDENT.

At a meeting held April 29th, 1872, the following resolutions were unanimously adopted by the St. Louis Board of Trade:

Resolved, That we regard the recent Lecture of Professor Waterhouse on Skilled Labor of such public value as to merit our official sanction, believing that its impressive facts and convincing reasonings would, if widely circulated, exert an important influence upon the material interests of Missouri. Therefore

Resolved, That the President of the Board be instructed to wait upon Professor Waterhouse and solicit a copy of his address for publication.

THE ECONOMIC VALUE

OF

SKILLED LABOR IN MISSOURI.

Of the useful and æsthetic arts, some were discovered and others adopted by our city for the promotion of the public interests.——
Nor do I wish to speak upon subjects whose discussion will confer no practical benefit, but rather upon those topics whose treatment will tend to ameliorate the condition of mankind.

ISOCRATES.

While feeling a reverent admiration for the higher departments of abstract thought and æsthetic culture, I do not sympathize with the fashionable depreciation of utilitarian studies. In some minds the grandeur of a thought seems to be proportioned to its uselessness, but it may be doubted whether knowledge for its own sake is better than knowledge for the sake of mankind. The progress of civilization, in which industrial art has been so important a factor, attests the truth that a devotion to material interests is not necessarily sordid. It is upon the foundations of *practical* thought that education and religion have reared their finest structures. Even the halls of this University owe their existence to the commercial success which amassed the means of their erection—to the intelligent and appreciative liberality which devoted to the service of culture the wealth which business sagacity had accumulated.

The postulate of Archimedes is a universal need—to move the world there must be a material stand-point. The creative genius which devotes its energies to cheapening the necessaries of life is

an efficient ally of moral progress. The successful conduct of any business demands and develops a special scholarship, which is not less valuable as a means of discipline, because it is so useful as a source of wealth. The business man may be narrow, but so may the scholar; and in either case, the narrowness results not so much from the necessities of the vocation, as from the character of the man. But to comprehend the broader relations of trade and manufactures requires a depth of insight, breadth of induction, mastery of facts, knowledge of political economy, mechanics and chemistry that will test the capacities of the best minds. The executive ability, soundness of judgment and knowledge of human nature which are essential to a symmetrical and useful development of faculties are evoked, not by processes of abstract thought, but by the experiences of business life. A recognition of the fact that some of the best trained minds in every community have been disciplined exclusively in the schools of active industry will not permit me to speak with disparagement of the professional scholarship which a devotion to business develops.

THE TRIUMPHS OF SCIENCE.

Applied science has transfigured the world. With Midas' touch it has created the wealth of nations and transmuted every object into gold. It has apprenticed the elements, invested the earth with a nervous system, endowed machinery with the attributes of intelligence, utilized the resources of nature, disciplined mental powers to greater efficiency, elevated and beautified human life. It has brought nations into nearer neighborhood, enlarged their exchanges and strengthened their friendship. It has relieved the severity of human toil, multiplied domestic comforts and increased the means of refined enjoyment. From the analysis of a planet to the observation of microscopic life, there is no department of physical research which it has not invaded. On every field of battle with ignorance it has won rich spoils of victory. It has fortified our faith

with stronger proofs of a divine cause and broadened the borders of Christian civilization. Indeed, the spiritual efficacy of mechanical and chemical appliances has been one of the potent forces of modern reform.

It would be difficult to exaggerate the moral power of machinery in ameliorating the condition of mankind by the diffusion of knowledge and the promotion of culture. But it is the economical aspect of our subject which to-night solicits attention.

CAPITAL AND LABOR.

I shall be obliged to omit the discussion of the relations between capital and labor. Even a brief treatment of this topic would exceed the narrow bounds of a single lecture. This omission, however, occasions less regret from the fact that the relations between capital and labor are less susceptible of control by discussion than the immediately practical interests which to-night demand consideration.

RAW MATERIALS AND WAGES.

The enhanced values of manufactured products strikingly illustrate the wealth-creating energy of skilled labor. Ceramic art converts a few grains of comparatively worthless kaolin, quartz and feldspar into a Sevres vase costing $5,000. Metallurgical skill transmutes ten cents' worth of iron ore into $10,000 worth of steel springs. Textile craft increases a hundred fold the value of the materials which are fabricated into point lace, Cashmere shawls, Brussels carpets and Gobelin tapestries. Belgian lace-thread, even before it has received its highest value in the finished beauty of the gossamer tissue, is worth five hundred dollars a pound. From a window-pane to the field-glass of a telescope, from the toy wagon of a child to the mammoth engine of an ocean steamer, from a photograph to a Titian, there is not a production in the whole range of articles of use or virtu that does not show the influence of skilled labor in appreciating the value of raw materials.

The effect of dexterity upon wages is also equally conspicuous. The inexpert workman always receives the lowest remuneration. But as the hand gains a deftlier cunning, and the mind a clearer intelligence, so the rate of compensation advances. The ignorant laborer who can barely earn a living may acquire a scientific skill that will enable him not only to amass a fortune, but also to promote the material interests of the world.

THE FORTUNES OF INDIVIDUALS.

Nearly a century ago, there lived in an English hamlet a lad whose history fitly illustrates my argument. His father was a humble laborer. By unremitting toil, he was barely able to procure the means of subsistence for himself and family. In his ceaseless struggle with poverty, he was cheered by no hope of preferment, no leisure for healthful recreation, no opportunity for self-improvement. The son was early compelled to assist his father in procuring the means of livelihood. At the age of nine, he was earning two pence a day; at fourteen, he was tending the furnaces of a colliery engine; at eighteen, he did not know a letter of the alphabet; but before he was twenty, partly by unaided efforts and partly by instruction in night schools, he had mastered the elements of reading, writing and ciphering. From this time his progress was rapid. Quickened by the impulses of genius and guided by a natural aptitude for mechanics, he devoted himself assiduously to the study of civil engineering. As his scientific attainments qualified him for more important positions, he was promoted to higher trusts, till at length he became one of the foremost engineers of the age, the father of the railway system, and the builder of great public works. Wealth, fame and usefulness crowned his success. With a natural patent of nobility, far grander than the title of princes, he could well afford to reject the honor of knighthood. Skilled labor had received its reward.

His son was reared under more favorable auspices. A scientific education, enriched by the experience of his father, was a

rare discipline for the duties of professional life. The energies of his powerful mind, utilized by technical training, left their impress upon the fortunes of mankind, and constructed upon both continents works of public usefulness and enduring fame. These examples, so memorable in the history of civil engineering, are full of weighty suggestions. The father and son were gifted with an extraordinary similarity of natural endowments. The chief difference in their careers was due to the effect of scientific teaching. More than one-third of the father's life, with all its possibilities of usefulness, was squandered through want of education. For many years after he had reached manhood, and while he might, if he had been properly educated, have been building the great highways of commerce, he was toiling with slow and painful progress through the rudiments of mathematics. And during all these years the world was losing the service of his splendid abilities. His lack of early training was a life-long impediment. His progress was often obstructed by problems whose solution would have been facilitated by an acquaintance with the formulæ of science. In the first years of professional service, his mind was perplexed with practical difficulties which a knowledge of mechanical and physical laws would have enabled him easily to surmount. The scientific information, which cost the unaided engineer years of valuable time and dearly-bought experience, could have been acquired in a few months in a technological school.

But the son spent his earlier years in training his faculties for professional service, and, at an age when his father had scarcely mastered the alphabet, he was a learned engineer and the superintendent of important public works. His great powers were fully utilized for the benefit of mankind. None of his time and usefulness was lost through lack of early instruction.

It would be difficult to illustrate by more impressive examples the value of technical instruction.

But while a genius like that of the Stephensons is granted to

few men, the principles of political economy which their lives inculcate measurably apply to the humblest departments of skilled labor. There is no pursuit so lowly that its follower may not increase the utility and value of his services by the acquisition of an intelligent dexterity.

THE WEALTH OF EUROPE.

Before discussing the application of skilled labor to the resources of Missouri, it will be well to investigate the polytechnic causes of foreign wealth. Differences in the various countries of Europe in wages, rates of interest and expense of living affect the cost of production, but they do not alone account for the relative superiority in manufactures. The nations which enjoy the most favorable industrial conditions are not always the foremost in manufacturing prosperity. The great secret of European success is skilled labor. It is this which develops national wealth and controls the tidal movements of commerce. Without it, no country can maintain an ascendancy in any department of manufactures. An active, vigilant, progressive competition would soon wrest the sceptre of industrial supremacy from the hand of an unskilful rival.

In Europe, skilled labor is fostered by the State. Hundreds of industrial and polytechnic schools have been liberally endowed and sustained by the government. The polytechnic buildings at Stuttgart and Munich cost 1,000,000 florins each, and the liberality of their endowment equals the splendor of their construction. Under the imperial government of France, an annuity of $200,000 was given to three technological schools, while a yearly grant of $400,000 was bestowed upon academies of higher art. Since 1852, the South Kensington Museum of Industrial Art has cost the British government $5,000,000, and the yearly appropriation for the encouragement of technical skill is $400,000. Emperors have deemed such institutions worthy of liberal patronage, and prime ministers have labored to

ensure their success. The means of public-spirited citizens and the services of distinguished men of science have been devoted to their advancement. The result sanctions the wisdom of these efforts and expenditures, and attests the profitable economy of skilled labor.

The copious wealth which flows along the channels of successful manufactures springs from a polytechnic source. In Europe there is scarcely a fine or useful art that is not fostered by special schools of instruction. Technical academies promote the growth of every leading industry. There are "schools for instruction in the arts of designing, engraving, coloring, dyeing, silk and ribbon weaving, lace making; of the making of horological instruments of various kinds; stone-cutting and general carving; of manufacturing the most delicate patterns and elegant forms of glassware; of working the metals—both useful and precious—into nearly every variety of form, for the consumption of the most refined and cultivated nations—schools, likewise, of various grades for instruction in the principles and practice of the more complex and comprehensive arts of mining, engineering, agriculture, etc." These schools are taught by skillful professors, furnished with libraries of technical science and equipped according to their varying requirements, with laboratories, workshops, museums of models, and collections of materials in the crude state and in the various stages of manufacture. It may be stated, as an evidence of imperial liberality in providing facilities for artistic illustration, that the French government recently distributed to the schools of Paris 35,000 models of the finest workmanship and taste for the instruction of little children in the art of drawing and design. It is obviously impossible, within the limit of an hour's discussion, fully to describe the peculiarities of the several schools. The precision of detail must yield to the vagueness of generalization. In all of these institutions, learned professors elucidate the principles and applications of industrial science. Every step, in the best processes of

converting raw materials into the finished product, is traced with minute care and philosophic exposition. The wastefulness of unskilful methods and the economy of scientific treatment are demonstrated. In the manufacture of fine silks and woolens, France stands pre-eminent. In lustre and brilliancy of impression, in exquisite taste, in beauty of design and harmony of colors, French fabrics rival the productions of the artist's pencil. This supremacy is not due to accident nor to the happy conceptions of untrained inventive skill. The consummate art which in these higher departments of industry controls the taste, fashion and trade of the civilized world, is the result of scientific study and discipline. Even the climatic and physical conditions under which the crude material is produced are carefully investigated, and every process of cleansing, bleaching, carding, spinning, weaving, dyeing and finishing is studied under the fullest illumination of modern science. Creative minds strive to devise better chemical methods, improved machinery, finer patterns and more elegant combinations. Elaborate expositions of the principles which control the harmonious blending of colors are illustrated by the finest products of textile art. Industrial æsthetics constitutes an important part of the course. The cultivation of taste begins in childhood. Little children are taught to observe every form of grace and symmetry, every beauty and variety of floral tint, every splendor of the sunset sky. The effect of this culture is discernible not only in the superior workmanship of the educated artisan, but also in the higher taste and general æsthetic refinement of the French people. But what are the commercial results of all this devotion to industrial science? France is to-day supreme in many of the higher branches of manufacture. The economical significance of this supremacy may be illustrated by a few statistics.

In 1863, the looms of Rheims produced $16,000,000 worth of woolen fabrics; 55,000 workmen were employed in this in-

dustry. In 1864, the value of the higher woolen manufactures of Roubaix was $40,000,000.

In 1863, France exported woolen goods of superior quality to the amount of $56,600,000. In 1866, the silk ribbons fabricated in the mills of Saint Etienne were worth $12,000,000. Out of a population of 90,000 people, 23,600 were engaged in this branch of manufacture.

In 1867, France sold $40,000,000 worth of silk goods to her British rival.

And in 1860, the exports of French silks amounted to $70,000,000, and the aggregate product was valued at $140,000,000.

Such are some of the practical results, representative of a wide range of manufactures, which are almost exclusively due to the influence of industrial schools. Wherever polytechnic instruction has been most general and thorough, there have sprung up those prosperous manufactories which have developed cities with an American rapidity of growth and raised impoverished populations to competence and the opportunities of education.

In 1830, Flanders employed more than 275,000 workmen in the manufacture of flax. But subsequently the mechanical improvements of other countries paralyzed this industry and involved a people, dependent upon it for their means of support, in suffering and ruin. In this extremity, the Belgian government resorted to the establishment of technical schools. The experiment was successful, and from that day the Belgian mills began to regain their former prosperity.

In 1851, the British government appointed commissioners to investigate the causes of decline in English manufactures. The report ascribed this decline to a conspicuous deficiency in technical instruction, and the government, seriously alarmed by the depression of manufacturing industry, loss of trade, and the conquests of foreign skill, at once instituted a general sys-

tem of polytechnic instruction. The influence of this training soon manifested itself in the greater economy of manufacture, superior excellence of the product, and renewed vitality of trade. This example forcibly illustrates the importance of industrial schools. Cheap capital and fuel, together with educated skill, have made England the workshop of nations and given her almost a monopoly of all the lower grades of cotton and woolen goods. The value of this monopoly, which skilled labor will enable her to preserve, may be inferred from the following figures.

In 1867, England manufactured 380,000,000 pounds of wool, and the product, independent of worsted goods, was worth more than $100,000,000. In 1866, nearly 900,000,000 pounds of cotton were fabricated in English mills. The total value of the product was more than $500,000,000, of which $248,000,000 worth was exported. In 1870, British exports, almost exclusively manufactures, amounted to nearly $1,000,000,000.

It is not strange that the English government was alarmed by the jeopardy of such vast interests, and that it should strenuously cherish the technical art which was an effective means of their preservation.

DOMESTIC AGRICULTURE.

Skilled labor, which has been productive of such enormous amounts of foreign capital, is to-day the supreme material need of Missouri. The enrichment of its magic touch would be felt throughout the whole range of our industries, but nowhere would the economic worth of technical skill be more conspicuous than in the operations of agriculture. In this country there has been a strong prejudice against scientific husbandry, but this feeling cannot rest upon any tenable basis of fact or reason. The application of scientific truth to every other department of practical industry has proved of the highest economic value, That agriculture is no exception to the universality of this prin-

ciple is shown by the surprising results which scientific farming has already achieved. Observe the progress in agricultural machinery. A few years ago, a friend of mine who was traveling in Greece saw some rustics vexing the earth with a knotted stick tied with ropes to the horns of oxen. The advance from this rude implement to the steam gang-plow of England is immense. The value of our improved reapers lies not only in the economy of human muscle and greater power of accomplishment, but also in that rapidity of operation which permits laborers to attend to other work till the full maturity of the cereal harvests, and then to garner them quickly with but slight exposure to damage by storm. The annual saving by this speedy rescue from the destructive force of the elements must amount to millions.

It is probable the world never before saw such perfect breeds of domestic animals as the scientific propagation of England has developed.

Skill in grafting, or in combination of varieties, has produced a marvellous improvement in the richness and delicacy of our apples, pears, peaches, grapes and strawberries. Through the beneficence of science, the modern laborer enjoys fruits of a more delicious and exquisite flavor than ever gratified the taste of an ancient epicure.

It is science that preserves the perishable fruitage of summer for the luxurious dessert of mid-winter, and concentrates meats and farina for Arctic voyage or sanitary use. It is science that, by the application of improved fertilizers, increases the bounty of our harvests, and restores the productive energy of exhausted soils. It is science that compels the sentinel lightnings to herald the approach of storms and to guard our property on land and sea against the elemental forces. Who then shall dare to say that science has been of no service to husbandry?

The European schools of agriculture are equipped with a liberality befitting their importance. The Russian school at Petrovs-

koi is sustained by an imperial annuity of $100,000. The Austrian farm at Krumau originally comprised 300,000 acres. All the schools devoted to agriculture are furnished with laboratories and workshops, improved implements and machinery, models and products; and the farms are supplied with the finest breeds of animals, the choicest varieties of cereals and vegetables, and the best selections of plants, vines and fruit trees. Some of these schools have factories for practical instruction in the manufacture of vinegar, starch, sugar, wine, etc. Thus, every branch of agriculture is enlightened by the tuition of science. The economic results of skillful tillage justify the expense of agricultural schools. It is hardly an extravagance of rhetoric to say that the chemical discoveries of Baron Liebig have increased the harvests of the civilized world.

I hope the time is not far distant when the European system will be extensively introduced into Missouri. Then its garners will overflow with the larger returns of intelligent cultivation, and its greater prosperity rest upon a scientific ground-work. Then the analysis of soil and vegetable, the special relations of climate to production, the conditions under which foreign plants and animals can be naturalized, and the applications of economic botany will be subjects of profitable investigation. Then the cultivation of fishes will be a luerative employment. Then veterinary skill will measurably rescue our domestic animals from the ravages of epidemic disease, and entomological science, sensibly arresting the devastations of insects, will annually save a wealth of fruits and cereals that would be more than sufficient for the erection and endowment of an agricultural college. Then farming, raised to the dignity of a science, will furnish not only ampler means of material greatness, but also exhaustless resources of philosophic study and expanding thought.

COMMERCE.

Educated skill is the directive power of modern commerce. High mercantile success implies broad views and sagacious combinations. Only large, resourceful and well-informed minds can control the great interchanges of nations. The untrained merchant can seldom successfully compete with a well-disciplined rival. Commerce is no exception to the general truth that knowledge and skill are guarantees of victory. A wide range of professional learning lies open to the merchant. The mysteries of book-keeping; the principles of banking and insurance; local wants and products; the inter-relations of demand and supply; the causes of fluctuations in prices and rates of exchange; geography and channels of communication; processes of manufacture, adulterations, and the impositions of trade; common and international law; commercial history and political economy, challenge investigation and reward the intelligent student with broader visions of mercantile life and greater assurances of personal success.

The youthful merchants of Missouri should ever remember that the great prizes of commerce are always won by superior knowledge under the guidance of practical skill.

MANUFACTURES.

In treating the application of skilled labor to our manufactures, the multitude of topics that solicit consideration is simply bewildering; time permits but a hasty glance at subjects which only an elaborate discussion can render interesting.

The dexterity of English manufacturers enables them to purchase the cotton of India, pay the profits of production, incur the cost of manufacture, defray the expense of a double transportation, and yet under-sell the native products in a country where ten cents are liberal wages for a day's work. And American ingenuity has, in certain branches of manufacture,

triumphed over the cheapness of British labor and capital, and profitably exported to England and the continent locomotives, sewing-machines, watches, and coarser cotton fabrics. It will, then, in this discussion, be assumed that skilled labor can achieve immediate success in many departments of productive industry, and an ultimate independence of European manufactories. Domestic skill will yet fabricate our wool, cotton, flax and silk into the myriad products for which we are now paying so costly a tribute to foreign looms.

In 1871, England bought of the United States more than $180,000,000 worth of cotton, and by the application of textile skill, realized a net profit larger than the original cost of the raw material. This single fact shows the possibilities of opulence which cotton mills in our own State would enjoy.

Iron of almost every useful variety is found in more than sixty counties in Missouri. According to the sober calculations of geology, this State contains 1,000,000,000 tons of iron ore, and 100,000,000,000 tons of coal. Yet the actual revenue which Missouri derives from this vast mineral wealth is far smaller than that of less favored regions. In 1871, this State produced about 85,000 tons of pig iron, worth something less than $4,000,000; in the same year England made from very inferior ores more than 6,000,000 tons of pig iron, worth in the *crude* state nearly $100,000,000. The annual productive value of the iron and coal mines of Pennsylvania is $120,000,000. Of the 2,000,000 tons of railway iron annually consumed in the United States, by far the larger portion is required for the roads of the Mississippi valley. While Missouri has such natural facilities for supplying this demand, most of these bars are imported, and the very rails that run to our mountains of iron were rolled in English mills. Capital and skilled labor will yet provide domestic supplies for every demand of hardware.

Possessing more than 15,000 square miles of coal, rich with inexhaustible stores of motive power, Missouri is yet largely dependent upon adjacent States for its supplies of fuel.

With galena enough in her mines to satisfy the wants of the whole Mississippi valley, our State imports lead from Europe and even from China.

Our abundant resources of copper, nickel, zinc, hydraulic cement, fire-clay and granite, are waiting for the hand of skilled labor to utilize them for the service of man. Vast quantities of cobalt, baryta, and ochres of every hue lie embedded in the soil of Missouri, ready for technical art to convert them into valuable paints. Our quarries are full of richly-veined and beautifully mottled marbles for the embellishment of our homes.

Kaolin, of superior purity for porcelain, and sand of the finest quality for glassware, exist in Missouri in exhaustless abundance. With these materials, skilled labor could create great and profitable industries. The example of Belgium, which twenty years ago produced 50,000,000 square feet of sheet glass per annum, Missouri would do well to imitate.

Iron pyrites, from which sulphuric acid is made, occurs in unlimited quantities in this State. This is a fact of great economic moment. No other chemical agent has such general use and value in the practical arts. The success of many of our most important industries depends upon a cheap abundance of this material. This acid is an essential element in bleaching, dyeing, calico printing, in the refinement of coal oils, and in the manufacture of super-phosphates, carbonate of soda, glass, soap, candles, etc. It is estimated that in Missouri alone the annual consumption of sulphuric acid amounts to 3,000,000 pounds. It is fortunate for our material interests that the State contains such exhaustless sources of this powerful industrial agent.

France is enriching itself by the annual production of 1,200,000,000 gallons of wine. Chemical analysis, meteorological

observation, and practical experience show that we have a soil and climate admirably adapted to the culture of the grape. With 10,000,000 acres suited to the growth of the vine, the vintages of Missouri ought to equal in extent, quality and productiveness the best wines in Europe. But this great source of wealth can only be unsealed by the hand of skilled labor. The successful competion of some of our native brands in the wine markets of Europe reveals the brilliant possibilities of our grape culture.

Thus far only the utilization of our own resources has been discussed, but there is no reason for any such narrow limitation of our productive energies. The manufactories of England bring their crude material from every quarter of the globe.

I have long thought that St. Louis, with its comparative nearness, partial water transportation, and cheap coal, possessed unusual facilities for the reduction of the Rocky Mountain ores. Our northern rival has already established smelting works for this purpose. St. Louis has too long neglected a rare opportunity of establishing a great and lucrative industry. The mountains invite us to relieve their distended veins and infuse their golden currents into our own circulation. Only an unreasonable spirit of self-denial can induce us to decline so generous an invitation. The silver ores of Utah are carried to Pennsylvania, New Jersey, and even Wales for reduction. Two hundred and fifty car loads a month have been sent to Swansea, and recently one Welsh firm had at their works $600,000 worth of Utah ores. It is said that the ocean freight alone—$6.60 a ton in gold—is equal to the cost of refinement in this city. If our mountain ores can be profitably transported 4,000 miles for reduction, the financial success of smelting works at St. Louis cannot reasonably be doubted. Large quantities of these ores are now shipped to Wales by way of San Francisco and Cape Horn—a distance of not less than 15,000 miles. In 1870, the amount of ores exported from Utah and Colorado for foreign reduction, was more than 100,000 tons. This is an exhibition

of energy which our citizens should emulate. Reductive works would also create kindred industries and our metropolis would become the great central manufactory of gold and silver ware. Artistic design and decorative skill are important elements in the value of such products.

CIVIL ENGINEERING.

Civil engineering is a branch of skilled labor too essential to be ignored in a formal discussion of the means of developing our resources. Its usefulness is conspicuous in the determination of legal bounds, in the sewerage which preserves the health of cities, in the drainage which reclaims malarious districts for fruitful tillage, in the water-works which supply towns with copious streams of healthful water, in the tunnels which undermine lakes and pierce mountains, in the bridges which span great rivers, in the canals which open new channels of communication between states and continents, in the railroads which facilitate domestic exchanges, in the steamships which bear the commerce of nations, in the machinery which impels the mightiest industries. But these works, without which our present civilization would be impossible, are the exclusive achievements of scientific skill. The civil engineer must be thoroughly conversant with mechanical drawing, the constructive principles of machinery, the tensile and compressive strength of materials, the dynamic effects of temperature and atmosphere, the static and hydraulic power of water—in fine, he must be familiar with mechanical forces, chemical properties, physical laws, mathematical science, and executive management, or he cannot command high success in his vocation. The calculations upon whose exact accuracy the erection of our great St. Louis bridge depends fill a large volume. But the skilled labor of the civil engineer is indispensable to a full development of the resources of Missouri. New avenues must be opened to our agricultural and mineral wealth. In many localities, our treasures

of iron, lead and coal have but little present worth for want of means to transport them to market. The vast forests of excellent timber which cover the surface of southern Missouri are now comparatively valueless, in consequence of their inaccessibility. The skilful engineer, providing facilities of access and transfer, will be an important factor in our industrial development.

GEOLOGY, MINING, AND METALLURGY.

The millions which England and Germany have spent in the prosecution of geological surveys and the maintenance of schools of mining and metallurgy have proved an enriching expenditure. The technical science acquired in the schools and utilized in the surveys has developed a mineral wealth a thousand fold greater than the cost of instruction and exploration.

There are, in all the world, few richer fields for geological investigation than the mineral formations of Missouri; and in these fields only skilled laborers command employment. Economic geology will be one of the plastic forces of our greatness. The geologist will examine the water power of the state and guide the manufacturer to the best mill sites; analyze soils and reveal their adaptations; develop building materials, sands, clays, ochres, and cements; indicate the position and extent of mineral veins, ores and deposits; and, by his knowledge of formations, modes of occurrence, animal and vegetable fossils, save the inexperienced miner many useless and costly experiments. The geologist, verifying his scientific researches with the wonderful diamond drill, can point with unerring accuracy to the buried treasures of Missouri. Mining and metallurgy supplement the labors of geology. To construct tunnels, sink shafts, raise ore, expel gases, secure ventilation, remove water, manipulate compressed air and the new explosives, economize motive power and mechanical forces, analyze fuels and fluxes, construct furnaces, utilize waste gases, control the chemical operations of smelting and refining, forecast the cost of works, and understand

the administration of mines, furnaces and workshops—these are duties whose economic discharge requires educated ability.

For the following examples of what skilled labor is capable of accomplishing in these departments of industry I am indebted to Prof. Potter. The ore in the district of Cleveland, England, has only 28 or 30 per cent. of iron. Our Missouri ores contain more than 50 per cent. of iron. Yet under the rigorous treatment of science, the Cleveland district produces from its inferior ore more and cheaper iron than any other region in the world. Where, less than a quarter of a century ago, there was not one house, there is now a population of 100,000 people, with an annual production of nearly 1,900,000 tons of pig iron.

The total value of the crude metals, coal and other minerals of Great Britain in 1870 was almost $240,000,000. Truly the results of skilled labor are not insignificant.

The lead ore of Freiburg, Saxony, is so extremely poor that in this country it would not, under existing conditions, pay the cost of reduction. But in 1867, an exhaustive scientific refinement extracted from 31,000 tons of ore 65,000 pounds of silver, 4,660 tons of lead, 1,200 tons of sulphur, 604 tons of zinc, 160 tons of arsenic, 70 tons of copper and 12 pounds of nickel and cobalt, with a total value of $1,393,885, and now a more skilful concentration in the treatment for other metals swells this aggregate by an annual addition of $30,000 of gold and bismuth, which even an analysis of the original ore failed to detect. Thus the economy of science compels an inferior ore, which here would simply be thrown away, to yield ten valuable and remunerative products.

Chemical superintendents are employed at most of the iron and steel works in Europe. Is it merely a coincidence that the greatest metallurgical and financial success is always found at those works which are under the constant supervision of professional chemists?

In foreign schools of mining and metallurgy, not only every

step from the opening of the mine to the completion of the metal product is elaborately taught, but the mind is trained to extreme vigilance of observation. Peculiar appearances of ore, novel behavior under treatment, the slag of the furnace, the dust of the refinery, and the gaseous condition of the surrounding air are carefully investigated for possible suggestions of more economical processes.

What wealth such skill, operating on the vast mineral resources of Missouri, would develop!

CHEMISTRY.

Chemistry, too, will be one of the great formative energies of our industrial prosperity. Many of the most brilliant and useful achievements in the domain of practical art have been wrought by economic chemistry.

This science sustains nearly the same relation to the industrial arts that air does to animal life. There is scarcely an article of use or beauty ever devised by the ingenuity of man that is not in some way indebted to economic chemistry. It is this science that provides comforts for the humble home and luxuries for the imperial palace; that reclaims waste lands and refines metals; that discovers remedies, disinfectants and anæsthetics; that derives from coal-tar the exquisite aniline hues, and forms the colors which embellish our fabrics and glow upon the canvas; that extracts the fragrance of a thousand flowers from the refuse of the stable, the flavor of pine-apple from putrid cheese, and the essence of pears and apples from fetid fusil oil; that forms artificial ice in tropic lands; that perfects the light which beacons mariners to safety; that works the infinitely varied miracles of telegraphy, photography and metallurgy; that moves mighty industries and cheapens the necessaries of human life. What chemistry has done to lessen the price of common articles a single example will illustrate. Formerly ultramarine was worth more than its weight in gold. But chemical skill has reduced the

cost from $50 to 50 cents a pound. The annual value of the chemical products of France is $250,000,000. There is no more fruitful field of applied science than economic chemistry, and none which I would more earnestly urge the youth of Missouri to cultivate. But its vast harvests can be gathered by no unskilled hand. Only scientific culture can garner its golden fruitage.

ENTERPRISE AND INVENTION.

Thus even a general discussion of the applications of skilled labor to some of our leading interests forces the mind to a conviction of its transcendent value in every branch of industry. One of the grand advantages of polytechnic training is that the educated workman can avail himself of the best means of effecting his end. He wastes no capital in impracticable experiments and squanders no time in acquiring the costly lessons of untaught experience. No plans are disheartened or frustrated by ignorance of physical laws. But all the forces and economies of science are his business partners. Enterprize, too, is stimulated by a scientific knowledge of the means of accomplishment; and conceptions, which the unskilled mind might perceive but could not embody, are speedily realized through the agencies of science. But economy and productiveness are not the sole advantages of skilled labor. A technical education is a powerful incentive to invention and discovery. The significance of nature's hints is not always perceived by the unlearned mind, but the cultivated intellect trained to habits of scientific vigilance, is quick to take intimations. To the spirit of observation and inquiry which a professional culture develops the world owes many of its most wonderful achievements.

But few years ago, the polarization of light was regarded as a curious optical phenomenon utterly unrelated to human uses; but now, in all sugar refineries, the angle of rotation of a polarized ray is the unerring criterion of the requisite degree of refine-

ment. The sensitiveness of certain chemical substances to the action of light was long a useless fact, but behold what a miracle skill has wrought!

Now photography not only fills the earth with art and beauty but also promotes science, depicting the magnified planet and animalcule with a delicate perfection that manual art can never equal. Its latest achievement is to form surfaces from which impressions can be *printed*, and the pictures, struck off just like steel plate engravings, retain the exquisite softness and fidelity of the photograph.

For centuries, a subtile and seemingly worthless force was allowed to squander its energies, but now, under the discipline of science, electricity guards our homes from burglary, protects human life in the regulation of railroad trains, moulds type, spreads golden beauty over the baser metals, secures the operations of agriculture, regulates the movements of fleets, and controls the commerce and politics of the world.

For years, the spectrum of flame was considered the valueless discovery of abstruse scholarship, but now spectral analysis is an important agent in one of our mightiest industries. In the manufacture of Bessemer steel, a powerful current of air is forced through the molten mass of iron, chiefly for the purpose of consuming the excess of carbon. A mistake of a few seconds in the length of the process would ruin the product. Only the most experienced and critical eye could determine, from an inspection of the flame, the exact moment of highest excellence. Such skill was rare and costly. But now the spectroscope affords a cheap and infallible means of telling when the work is done. While the carbon lines are visible in the spectrum of the flame, the operation is incomplete; but when these lines disappear, the process is finished, and the air-blast must be instantly arrested.

The spectroscope enables an ordinary workman to determine the precise moment when the requisite chemical change has been

effected. Thus a curious physical discovery, apparently destitute of all practical value, has proved to be an efficient factor in a great industry. This novel use of the spectroscope is a beautiful illustration of the simplicity, certainty and economy of some of the processes of applied science.

To the infinitely varied applications of steam, whose motive breath vitalizes every industry, we now add some of the finest effects in the coloring of woolen fabrics, and even engraving, by means of the sand-blast.

These examples prove not only the practical usefulness of scientific truth, but also the expediency of cultivating the inventive faculty. A single discovery often enriches the world. A polytechnic education, stimulating the inquisitive and creative power of the human mind, tends to develop one of the most productive forces known to political economy. Scientific research may yet discover other agents as useful as hydrochloric acid in bleaching, mercury in the refinement of metals, or sulphuric acid throughout the range of industrial art. It may yet devise a cheap and effective means of eliminating sulphur from iron without coking the impure coal. It may yet utilize electric energy as a motive power. It may yet so improve machinery, simplify chemical processes, and reduce the cost of living as to secure for our State a golden pre-eminence in manufacturing industry.

ACTIVITY OF BUSINESS.

Now, most of our raw material is exported, and nearly all our domestic wants are supplied by importation. One of the beneficent results of the introduction of skilled labor would be a more general establishment of home manufactories. This would save the immense sums which we are now paying away for double freightage, reward the producer with the larger net gains of a domestic market, utilize our resources, retain within our own State the cost and profits of manufacture, and inspire every industry with prosperous life.

THE PRESENT DUTY OF MISSOURI.

Never in our history has there been a more propitious moment than the present for the introduction of skilled labor. In Europe, the increasing expense of living, and the greater difficulty and cost in obtaining ores and coal lessen the advantages of the foreign manufacturer, while the social, political and industrial condition of Europe favors emigration. Missouri should avail itself of the auspicious opportunity. The introduction of educated skill is worthy of legislative encouragement. Trustworthy expositions of our resources, issued under official sanctions which will command confidence should be disseminated in foreign lands.

DOMESTIC INSTITUTIONS.

But the acquisition of European dexterity ought not to be the limit of our endeavors. Polytechnic schools of our own should be equipped with every facility for the professional education of the youth of Missouri. George Stephenson once wished to emigrate to America, but was prevented by poverty. The accomplishment of his purpose might have changed the fortunes of the world. The financial value of such a man is beyond the calculations of political economy. But our polytechnic schools may develop Stephensons of our own.

PERSONAL CHARACTER.

If it be alleged that the tendencies of a technical education are sordid, the charge is refuted by the logic of experience Throughout Europe, it is found that industrial training not only surrounds the artisan with competence and physical comforts, but also begets in him a spirit of inquiry and greater general intelligence. It raises *all* its beneficiaries to higher planes, and some to lofty eminence. The mind which has gained an exact knowledge of any branch of practical science is stirred with a restless desire for a deeper insight into the laws

and forces of physical nature; and the education that blesses the home with greater plenty and the means of mental culture also quickens the intellect with the spirit of scientific inquiry.

Before the establishment of technical schools, the industrial masses of Europe were generally poor and ignorant, and frequently profligate and lawless. Sunk often in sensual grossness, they were destitute of the virtues that ensure domestic happiness and the aspirations that guide to a higher life. But instruction, opening sources of purer enjoyment and disclosing possibilities of personal elevation, initiated a radical reform. It promoted civil order, public health, and private morality. Workmen who had been accustomed to squander their small wages in dissipation now spent their larger earnings upon the means of self-improvment; and strove to bestow upon their children the scientific culture whose practical value they had experienced in the advancement of their own fortunes. With a clearer perception of their industrial, civil, and moral obligations, they became more intelligent artisans, more orderly citizens, and more exemplary men—teaching by personal proof the grand fact that even an economic education promotes not only the material welfare of States, but also the higher interests of morality and civilization.

HIGHER CULTURE.

Wealth naturally precedes culture in the order of national development. It is idle to talk of the charms of literature to him whose utmost efforts can barely procure a living, or to speak of the beneficence of universities to communities which lack the riches to build and endow them. On every side great possibilities fail for the want of means to realize them. But the *wealth* derived from the practical arts should not be the ultimate object of human aspiration. Applied science is grandly useful in raising the masses to higher levels of happiness, and giving them the means and opportunities of intellectual cultivation. I have no

fears that the wealth created by educated skill will be devoted to ignoble uses. History records no finer examples of intelligent munificence than those which embellish the annals of our own country. The consecration of private and public resources to beneficent charities, popular education and higher culture inspire an assured confidence that greater opulence would only be the means of a broader usefulness and a truer refinement. Then let the practical arts with utmost speed lay the material foundation of a higher civilization—a civilization that shall rise like the fair fabric of a Minervan temple, sacred at once to culture and adoration—a civilization whose spiritual wealth shall be far above all material riches, and whose refined art shall glorify the canvas with images of grace, chisel the marble into forms of celestial loveliness, and adorn the page with creations of poetic beauty.