Secretary of the Council, Asaph Hall, Jr., of Ann Arbor, Mich.

Secretaries of the sections, A. Mathematics and Astronomy, Edwin B. Frost, of Hanover, N. H. B. Physics, Frank P. Whitman, of Cleveland, O. C. Chemistry, Frank P. Venable, of Chapel Hill, N. C. D. Mechanical Science and Engineering, John Galbraith, of Toronto, Can. E. Geology and Geography, A. C. Gill, of Ithaca, N. Y. F. Zoölogy, D. S. Kellicott, of Columbus, O. G. Botany, George F. Atkinson, of Ithaca, N. Y. H. Anthropology, John G. Bourke, U. S. Army. I. Economic and Social Science, R. T. Colburn, of Elizabeth, N. J.

Treasurer, R. S. Woodward, New York, N. Y.

Invitations to hold the meeting of next year at St. Paul, Indianapolis, Colorado Springs and Buffalo were presented. Buffalo was selected, partly for the reason that there has come to be a sort of precedent for a meeting at Buffalo every ten years. The Association met at Buffalo first in 1866, the first meeting after the opening of the war; 1876 and 1886 saw the Association again there, and now in 1896 the visit to Buffalo will be repeated. It was also kept in mind that a strong effort is being made to have the British Association meet at Toronto in 1897, and that the west would furnish desirable places for a joint meeting of the two Associations.

Much more debate was occasioned in selecting the date for the next meeting. The meeting of this year, beginning as it did the fifth week in August, was felt to be too late, the early opening of the schools and some colleges preventing the attendance of many teachers. This year the meeting opened on Thursday; sections met on Friday; Saturday was devoted to excursions, and the Sections renewed their meetings on Monday. The break of two days was felt to be detrimental to the interests of the Association. The Council proposed that the first meeting and Vice-Presidential and Presidential addresses be on Monday, leaving four days of continual session for section work, and then at the close Saturday is left for excursions. Many of the members, however, felt that Tuesday would be the best day for opening, as travel on Sunday could be better so avoided. After prolonged argument the recommendation of the Council was adopted, and the meeting of 1896 will open at Buffalo at 10 A. M. on Monday, August 24th. It is hoped by this arrangement to avoid the considerable exodus of members which takes place under the present custom on Friday night. The subject is complicated by the Affiliated Societies, which now meet for the most part on Monday prior to the opening of the Association, and some of whose members desire to get away before it closes.

The relation of the Affiliated Societies has occasioned an increasing amount of discussion, some holding that they are very helpful to the Association, while others see in them a cause of diminishing interest in the Association. A committee was this year appointed to consider broadly the policy of the Association and its relation to the Affiliated Societies, and to suggest methods of improving the present state of affairs.

The close of the last session of the Association was marked by the presentation of a resolution of thanks, which was seconded with appropriate remarks by a number of members of the Association, and ably replied to by ex-Lt. Gov. W. H. Haile. Thus ended a meeting which, if small in number, was nevertheless one of the most successful and helpful meetings which the Association has known.

JAS. LEWIS HOWE,
General Secretary.

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*THE RELATION OF ENGINEERING TO ECONOMICS.**

IN the first page of Mr. J. R. McCullough's 'Introductory Discourse' (published

* Vice-Presidential Address delivered before Section D, Mechanical Science and Engineering, of the American Association for the Advancement of Science, at Springfield, Mass., Aug. 29, 1895.

in 1828) to his edition of Dr. Adam Smith's work, 'An Inquiry into the Nature and Causes of the Wealth of Nations,' he gives one of the best definitions we have of the science of political economy. "Its object," he says, "is to point out the means by which the industry of man may be rendered most productive of those necessaries, comforts and enjoyments which constitute wealth; to ascertain the proportion in which this wealth is divided among the different classes of the community, and the mode in which it may be most advantageously consumed."

The definition of engineering given by Tredgold, and incorporated into the charter of the British Institution of Civil Engineers, is 'The art of directing the great sources of power in nature for the use and convenience of man.' Rankine says: "The engineer is he who by art and science makes the mechanical properties of matter serve the ends of man."

Mr. George S. Morison, President of the American Society of Civil Engineers, in his address at the convention of the Society in June this year, says:

"Every engineering work is built for a special ulterior end; it is a tool to accomplish some specific purpose. Engine is but another name for tool. The highest development of a tool is an engine which manufactures power."

Comparing the above definitions of political economy and of engineering, we find they are closely related. Political economy, according to McCullough, points out the means by which the industry of man may be rendered most productive of wealth. If we asked the merest tyro in knowledge of human industry by what means industry might be rendered most productive, he would naturally answer, 'by the use of tools.' The engineer is the tool builder. His best work is the building of an engine which manufactures power, makes industry most productive and manufactures commodities which are the elements of wealth. Political economy, which points out the means by which industry may be made most productive, should, therefore, point out tools and engines. But, strange to say, the writers on political economy have almost entirely neglected to point out those means. Their 'dismal science,' as it is called, generally points out everything but tools and engines. It treats of buying and selling, of supply and demand, of rents, interest and wages, of tariffs, of money and currency, of land values, taxes, and what not; but, with rare exceptions, does not mention engineering, which is the most potent force in the economics of the nineteenth century.

Adam Smith, the first great English writer on political economy, writing in 1776, when he was, of course, not to be blamed for knowing nothing of the engineering of this century, said: "The greatest improvement in the productive power of labor, and the greater part of the skill, dexterity and judgment with which it is anywhere directed or applied, seem to have been the effects of the division of labor." He gives a famous instance of the division of labor in the manufacture of pins. One man, he said, might with difficulty make one pin a day, and certainly could not make twenty. But as the manufacture was carried on in his day, by division of labor one man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head, and so on, dividing the labor up among ten men, and eighteen different operations. Those ten men thus made between them 48,000 pins per day. Most writers on political economy have followed Adam Smith, and given division of labor the credit for making the greatest improvement in production, and neglected the still more important improvement, the introduction of machinery, by which the labor of ten men was all done by

a machine with one man tending it. But I find that Robert Ellis Thompson in his work on political economy (1875) mentions the case of the pin industry in its modern phase. He says: "An inventive mechanic has put together a machine that only needs to be fed with wire, well oiled and supplied with steam power, to turn out complete pins, sort them, and even thrust them into the papers in the right numbers and in straight rows."

The example of the pin industry may be taken as representative of what has taken place in every branch of productive industry. By the use of the steam engine and of other machinery the productive power of human labor has been increased a thousand fold, and engineering thus becomes the most important force which has caused an industrial and economic revolution throughout the civilized world, and the one subject of all others which should be discussed by a political economist.

Political economy being broadly the science of wealth, and since wealth is property, and property, according to some writers of the socialist school, is robbery, it may be well to get our bearings here, and see whether wealth is a thing to be desired or not. I quote here the words of Mr. McCullough in his 'Introductory Discourse,' above mentioned, and without further argument may say, that I agree with him entirely: "The acquisition of wealth is not desirable merely as the means of procuring immediate and direct gratification, but as being indispensably necessary to the advancement of society in civilization and refinement. Without the tranquillity and leisure afforded by the possession of accumulated wealth, those speculative and elegant studies which expand and enlarge our views, purify our taste, and lift us higher in the scale of beings, can never be successfully prosecuted. It is certain, indeed, that the comparative barbarism and refinement of nations depend more upon the comparative amount of their wealth than on any other circumstance. It is impossible to name a single nation which has made any distinguished figure either in philosophy or the fine arts without having been at the same time celebrated for its wealth."

Having thus settled the question of the desirability of wealth, let us consider what is the engineer's share in its production. The great forces of nature which the engineer utilizes for the production of wealth are the forces of wind and of running water, and the stored energy of fuel in the forests, peat bogs, coal mines and gas and oil wells. By far the greatest of these forms of stored energy is that of coal. Let us compare for a moment the work that can be done by a ton of coal with the muscular power of men. One man digging coal from the side of a hill can easily dig two tons, say 4,000 lbs. of coal, in a day. Another man running a boiler and engine can burn these same two tons under a boiler, and if the engine is a moderately good non-condensing engine using 3 lbs. of coal per indicated horse-power per hour, it will develop from the two tons of coal 133 horse-power for 10 hours, equivalent to the physical labor that could be done by 1,300 men. Thus a man's labor by means of coal and a steam engine can be multiplied 650 times. But if we use a large high-grade triple-expansion, condensing engine, it will require only half as much coal per horse-power, and then if we set the engine to work to mine the coal itself, through the agency of mining machinery, and to feed its own coal to the boiler by means of automatic stokers, we see that the effectiveness of man's labor can be still more vastly increased.

Let us consider some of the results which the engineer has been able to accomplish by the utilization of coal.

In my study of the subject of this address, while I have failed to find it properly treated

in any of the standard works on political economy to which I have had access, I have found it discussed in a more or less fragmentary manner in writings and addresses of numerous engineers, statisticians and other specialists, and since it is more convenient to quote largely from their writings than to write anything original, I will now trouble you with some quotations.

I first quote from a recent lecture by Mr. Edward Orton, State Geologist of Ohio, before the Ohio Mining Institute:

"All the great applications of the stored power of the world belong to the nineteenth century, and the most important of them belong to the last 50 years. What has been done within this century constitutes by far the most important chapter in the economic history of the race. Fossil power lies at the root and center of this unparalleled advance. In Great Britian alone coal does the work of more than 100,000,000 men. It adds to the wealth of these fortunate islands on this basis.

"The great powers, those that are making over the world, are steam and electricity. The steam engine lies at the bottom of by far the greatest industrial and economic revolution through which the race has ever passed, and steam is now being reënforced by the new motor, from which we justly expect so much.

"We note some further consequences of the discovery and use of fossil power on the large scale. We shall find the most striking characteristics of our day and age, so far as the material side of life is concerned, centering around this one element. What are these characteristics of the nineteenth century? There are no more distinctive features of our time than the two following: viz., the remarkable growth of cities throughout the civilized world and the unparalleled increase of the wealth of men. Both take their rise in coal; both are conditioned by its use in all their phases and stages. All modern manufactures are absolutely dependent on the stored force of coal. Machinery driven by this power is everywhere replacing the skilled labor of the olden time. Cities grow largely by massing the ruder labor that our modern factories can utilize.

"With this growth of cities in the modern world, a group of problems arises, all of which are new and of which we are obliged to work out the solutions. No other problems of equal gravity and urgency confront the statesman, philosopher or philanthropist of our day. All of them have their root in coal."

Mr. John Birkinbine, Past President of the American Institute of Mining Engineers, estimates that if only 1% of the consumption of fuel of all kinds in the United States, including coal, wood, oil and gas, were saved, it would be equal to 2,300,000 tons of coal per year. It is the work of the engineer to devise ways and means to accomplish this saving and more.

Mr. Chas. H. Loring, Past President of the American Society of Mechanical Engineers, in his Presidential address in 1892 thus spoke of the influence of the steam engine upon civilization:

"The civilizations of antiquity were limited to a few cities, and were based upon a slave labor, the slaves being drained from other places, which were thus doomed to deepening barbarism.

"The disgrace of the ancient civilization was its utter want of humanity. Justice, benevolence and mercy held but little sway; force, fraud and cruelty supplanted them. Nor could anything better be expected of an organization based upon the worst system of slavery that ever shocked the sensibilities of man. As long as human slavery was the origin and support of civilization, the latter had to be brutal, for the stream could not rise higher than its source. Such a civilization, after a rapid culmination,

had to decay, and history, though vague, shows its lapse into a barbarism as dark as that from which it had emerged.

"Modern civilization also has at its base a toiling slave, but one differing widely from his predecessor of the ancients. He is without nerves and he does not know fatigue. There is no intermission in his work, and he performs in a small compass more than the labor of nations of human slaves. He is not only vastly stronger, but vastly cheaper than they. He works interminably, and he works at everything; from the finest to the coarsest he is equally applicable. He produces all things in such abundance that man, relieved from the greater part of his servile toil, realizes for the first time his title of Lord of Creation. The products of all the great arts of our civilization, the use of cheap and rapid transportation on land and water, and of printing, density of population everywhere, the instruments of peace and war, the acquisition of knowledge of all kinds, are made the possibility and the possession of all by the labor of this obedient slave, which we call Steam Engine.

"We who were born under this benign influence but vaguely appreciate its value, and rarely recognize our obligations to it; existing civilizations would be impossible without it, and if human ingenuity finds no substitute for it they will perish with it.

"The steam engine is a machine which has been the prolific parent of other machines. It has caused the invention and construction of the immense plant of ingenious power tools employed in its own fabrication; it has caused the improvement of metallurgy as a science and of the various methods of metal manufacture as an art; it may be said to have created whole branches of important manufacture, and to have been the occasion of the invention of the immense mass of highly-diversified machinery, by means of which these manufactures are practiced; and, last and greatest, it has stimulated and directed the human intellect as nothing else ever has, and has done more to advance human nature to a higher plane than all which statesmen, generals, monarchs, philosophers, priests and artists have ever accomplished in the vast interval which separates original man from the man of to-day. It has raised man from an animal to something approaching what a great intelligence should be, by simply placing in his hands a limitless physical power capable of application in every conceivable direction and to every conceivable purpose."

The value of the invention of Bessemer steel to the human race is discussed as follows in an address by Mr. Abram S. Hewitt in 1890 ('Trans. Amer. Inst. Mining Engineers,' Vol. XIX., p. 518):

"The Bessemer invention takes its rank with the great events which have changed the face of society since the Middle Ages. The invention of printing, the construction of the magnetic compass, the discovery of America and the introduction of the steam engine are the only capital events in modern history which belong to the same category as the Bessemer process. They are all examples of the law of progress, which evolves moral and social results from material development. The face of society has been transformed by these discoveries and inventions.

"Steel is now produced at a cost less than that of common iron. This has led to an enormous extension in its use and to a great reduction in the cost of the machinery which carries on the operations of society. The effect has been most marked in three particulars: First, the cost of constructing railways has been so greatly lessened as to permit of their extension into sparsely-inhabited regions, and the consequent occupation of distant territory otherwise beyond the reach of settlement; second, the cost of transportation has been reduced to so low

a point as to bring into the markets of the world crude products which formerly would not bear removal, and were thus excluded from the exchanges of commerce; third, the practical result of these two causes has been to reduce the value of food products throughout the civilized world, and, inasmuch as cheap food is the basis of all industrial development and the necessary condition for the amelioration of humanity, the present generation has witnessed a general rise in the wages of labor, accompanied by a fall in price of the food which it consumes. * * * * These are material results, but they are accompanied with the slow but sure elevation of the great mass of society to a higher plane of intelligence and aspiration."

The increase of working power of the United States is thus shown by Mr. M. G. Mulhall, the great statistician, in the *North American Review* for June, 1895. The working power of an able-bodied male adult is 300 foot-tons daily; that of a horse, 3,000, and of steam horse-power, 4,000. On this basis the working power of the United States was at various dates approximately as follows in millions of foot-tons daily:

Year.	Hand.	Horse.	Steam.	Total.	Foot-tons daily per inh'b'nt.
1820	753	3,300	240	4,293	446
1840	1,406	12,900	3,040	17,346	1,020
1860	2,805	22,200	14,000	39,005	1,240
1880	4,450	36,600	36,340	77,390	1,545
1895	6,400	55,200	67,700	129,400	1,940
Gt. Britain 1895.	3,210	6,100	46,800	56,110	1,470
Germany, 1895.	4,280	11,500	29,800	45,580	902
France, 1895.	3,380	9,600	21,600	34,580	910
Austria, 1895.	3,410	9,900	9,200	22,510	560

Notice from this table how vastly the power of man is increased by the use of the steam engine, and in United States how great was the increase in the last 15 years.

The wealth of the American people, says Mr. Mulhall, surpasses that of any other nation past or present. "The physical and mechanical power which has enabled a community of woodcutters and farmers to become, in less than 100 years, the greatest nation in the world, is the aggregate of the strong arms of men and women, aided by horse-power, machinery and steam power applied to the useful arts and services of of every-day life. The accumulatian of wealth in the United States averages $7,000,000 daily."

The increase of wealth in the United States is shown as follows, according to Mulhall:

Year.	Total wealth, millions of dollars.	Wealth per capita.
1820	1,960	$205
1840	3,910	230
1860	16,160	514
1880	43,642	870
1890	65,037	1,039

Wealth per capita in different countries in 1890;

Great Britian	$1,260
France	1,130
Holland	1,089
United States	1,039
Belgium	840
Germany	730
Sweden	630
Italy	480
Austria	475

Average yearly wages per operative in the United States:

1860	$289
1870	302
1880	347
1890	485

Rural or agricultural wealth in the United States has quadrupled in 40 years, while urban wealth has multiplied sixteenfold.

	Millions of dollars.			Per cent of total	
	Urban.	Rural.	Total.	Urban.	Rural.
1850	3,169	3,965	7,136	44.4	55.6
1860	8,180	7,980	16,160	50.6	49.4
1870	15,155	8,900	24,055	63.0	37.0
1880	31,538	12,104	43,642	72.2	27.8
1890	49,065	15,982	65,037	75.4	24.6

During the last 20 years the increment of rural wealth has been almost uniform at $47 per head per annum of the number of rural workers. In urban workers the accumulation averaged $83 per annum, which suffices to explain the influx of population into towns and cities.

The increased productiveness of the farmer, due to his use of machinery, is shown as follows:

"An ordinary farm hand in the United States raises as much grain as three in England, four in France, five in Germany and six in Austria, which shows what an enormous waste of labor occurs in Europe because farmers are not possessed of the same mechanical appliances as in the United States.

"In the United States one man can feed 250, whereas in Europe one man feeds only 30 persons. Nor can we hope for a better state of things in Europe soon. So dense is the ignorance of most men, even among the educated classes, that they are convinced that all labor-saving appliances are an evil, and that the more persons there are employed to do any given work the better."

During a visit to Germany three months ago I learned of an instance of this ignorance among the laboring classes. My traveling companion saw three men cutting grass on a lawn with ordinary scythes and sickles. "Why don't you use a lawn mower?" said he, "then one man could do as much as three are now doing." "Don't talk to us about lawn mowers," said one of the men, "it is all we can do now to find work enough to earn our bread. If we had a lawn mower two of us would starve." They did not think that if their employer saved the wages of two men, the money would burn a hole in his pocket until he either employed it for some useful purpose, by giving employment to either the same two men or two others, or loaned it to some one who would employ it.

In the United States, however, the old-time opposition to the introduction of labor saving machinery as a harm to the laboring man, throwing him out of employment, has now almost died out among reasoning men, and it is generally acknowledged by men who have studied the subject that the steam engine and labor-saving machinery in general are the chief agents of the civilization of the latter half of the nineteenth century, and that they have increased the productiveness of man's labor, increased his wages, shortened his hours of labor, cheapened his food and clothing and given the average man comforts and luxuries which a century ago not even kings would have commanded.

Mulhall's 'Dictionary of Statistics' (1892) gives the following facts concerning the agriculture of the world. "Capital and product have more than doubled since 1840, but the number of hands has not risen 50 per cent.

Agricultural Capital of the World Millions of Dollars.

	Land.	Cattle.	Sundries.	Total.
1840	35,475	4,970	4,735	45,180
1860	59,310	7,810	7,495	74,615
1887	88,880	13,505	12,645	115,030

Agricultural Capital in the United States. Millions of Dollars.

	Land.	Cattle.	Sundries.	Total.
1840	2,000	480	500	2,980
1860	6,910	1,130	1,185	9,225
1887	12,800	2,505	3,175	18,480

"In the United States 9,000,000 hands raise nearly half as much grain as 66,000,000 hands in Europe. Thus it appears that for want of implements and of proper machinery there is a waste of labor equal to 48,000,000 of peasants."

The census returns of the manufacturers of the United States, 1880 and 1890, show the following:

	1880.	1890.	Increase per cent.
No. of establishments reporting	253,502	322,624	27.27
Capital	$2,780,766,895	$6,138,716,604	120.76
Av. No. of employees	2,700,732	4,476,094	65.74
Total wages	$939,462,252	$2,171,356,919	130.13
Cost of materials used	3,395,925,123	5,018,277,693	47.77
Value of products	5,349,191,458	9,054,191,458	69.27

Vast economic changes throughout the world have recently taken place as the result of the development of engineering. Mr. Edgerton R. Williams in his article on 'Thirty Years in the Grain Trade' (*North American Review*, July, 1895), says:

"In 1869 97% of England's population, say, 18½ out of 19 millions, were fed on English-grown wheat. In 1890, with a population of 25 millions, only 5 millions were supplied with English wheat, a falling-off of 77%. The decrease in wheat average in 40 years, from 1846 to 1886, was nearly 66%."

The tendency of population from the country to the cities is a consequence of the increased production of manufactures and of the decrease in the percentage of the total population required to produce the food of the world. This tendency in the United States is shown in the following census figures:

	Urban population, per cent. of total.				
United States.....	1850	1860	1870	1880	1890
Per cent.....	12.49	16.13	20.93	22.57	29.12

In the northern central division of the United States, in the past ten years, the urban element has nearly doubled, while the total population has increased only 25.78%. The increase in urban population is confined mainly to a few large cities.

The completion of the Trans-Siberian Railroad, and the extension of railroads in India and in the Argentine Republic will probably before long make Europe independent of the grain crop of America. Mr. Worthington C. Ford, Chief of the United States Bureau of Statistics, in the *North American Review* for August, says: "It is now the Argentine Republic which appears to have an almost unlimited power to grow and export wheat in defiance of any competition." The perfection of refrigerating machines—an engineering triumph—makes it now possible for Europe to receive its supply of meat from Australia and from the Argentine Republic, as well as from the United States. The introduction of modern cotton machinery into Japan and into India threatens the cotton trade of England with exclusion from the markets of Asia, one of England's greatest present resources. In Australia, according to Mr. Ford, the ranchmen are successfully overcoming one of the most serious obstacles to the extension of sheep raising, by sinking artesian wells and making pools or dams to retain the water for their stock—another example of the application of engineering in using nature's stored forces to overcome the resistance of nature. There thus appears to be no limit to the economic changes throughout the world which may yet be made by the use of engineering appliances.

Marked economic effects have attended the building, or failing to build, important highways in the United States of whatever kind where opportunity and need existed. The early topographical engineers of the country, including especially George Washington, who was an engineer by profession, foresaw that at whatever point on the Atlantic coast an outlet should be made for the products of the Ohio and Mississippi valleys, a great, probably the greatest, seaport would arise. Virginia was at this time far in advance of the other States, and especially of New York. * * * Washington urged the Legislature of Virginia to build a canal connecting the Ohio River and the James or Potomac, so as to place the outlet at Norfolk. His advice was not heeded. Subsequently New York, under the leadership of De Witt Clinton, constructed the Erie Canal, connecting Lake Erie, at Buffalo, with the Hudson, at Albany, then a stupendous feat of State enterprise in finance and civil engineering. Until that canal was built New York city had little more than the trade of the Hudson River valley. The building of the canal made New York the Empire State, and the city the commercial metropolis of the Union—Denslow, p. 150.

Who can estimate the economic value to the United States of that great feat of engineering, the building of the first railroad across the continent? What an increase of the wealth of nations has flowed from the opening of the Suez Canal, and what another

increase will follow the completion of the Nicaragua Canal!

Improvements in engineering methods often cause the destruction of vast amounts of fixed capital by the substitution of new appliances for the old. The British government expended in 1864–'70 £20,000,000 on a class of armored gunboats, which, before any use was made of them, were condemned as worthless, owing to the improvements in the construction of guns. It expended large sums on iron guns, which became useless by the substitution of steel guns, etc.

A telegraph company expended large sums of money in constructing a line through Siberia and Alaska, whereby to get telegraphic communication between New York and London via San Francisco and Behring Straits, which was made totally worthless by the laying of the first Atlantic Cable (Denslow, p. 81). Numerous canals and canal boats have been thrown out of use and allowed to fall into decay on account of the competition of railroads.

Between 1872 and 1880 a revolution took place in the construction and in the method of driving blast furnaces for making iron, so that of 700 blast furnaces running or in condition to run in 1872, probably not 50 are now on the active list, and although the production of iron has more than quadrupled since that date, only 480 furnaces are now on the list of existing furnaces, and more than half of these are out of blast. The destruction of capital involved in the abandonment of old furnaces is probably over $100,000,000. A similar destruction of fixed capital has followed the substitution of Bessemer steel for puddled iron, and the introduction of improved forms of rolling mills. A great decrease in the value of the iron mines of New Jersey, New York and Pennsylvania has followed the opening of better mines in Lake Superior.

One of the great achievements of engineering is the substitution of the factory system of labor for the old domestic system. The beginning of the factory system was in the decade of 1760–1770, when the spinning jenny, the spinning frame and the spinning mule were introduced into the textile industry, but it did not begin its full career of development until after Watt had perfected his steam engine about thirty years later. Has the factory system been a benefit to civilization? There is no better authority on this question than Mr. Carroll D. Wright, formerly United States Commissioner of Labor, and now Commissioner of the Census of 1890. He says: (Johnson's Cyclopædia, Vol. III., p. 265): "The factory system is in every respect vastly superior to the domestic system as an element of civilization, although this is contrary to popular impression and largely against popular sentiment. * * * Under the domestic system the home of the worker was the workshop also, and the wheels or looms disputed with the inmates for the room and the conveniences for house work. Small, close crowded, with bad air and bad surroundings, the hut of the domestic worker was occupied by a class which had not found, and cannot find, its like under the factory system, for, as a rule, the operative of to-day occupies a home even in the factory tenement or boarding house superior in every sense to the home of the domestic worker.

"Under the domestic system of industry grew up that great pauper class in Great Britain which was a disgrace to civilization. It continued to grow, until one-fourth of the annual budget was for the support of paupers. * * * The domestic labor's home was far from having the character poetry has given it. Huddled together in what poetry calls a cottage and history a hut, the weaver's family lived and worked without comfort, conveniences, good food, good air, and without much intelligence. Drunken-

ness and theft of materials made many a house the scene of crime and want and disorder. Superstition ruled, and envy swayed the workers. Ignorance under the old system added to the squalor of the homes of the workers under it, even making the hut an actual den, shared in too many instances by the swine of the family. The home of the agricultural laborer was not much better; in fact, in Great Britain and France he has to a great degree continued in his ignorance and in his degraded condition.

"One of the positive results of the factory system has been to enable men to secure a livelihood in fewer hours than of old. This means intellectual advancement, for, as the time required to earn a living grows shorter, civilization progresses. * * * The fact that the lowest grade of operative can now be employed in factories does not signify more ignorance, but a raising of the lowest to higher employments. This process is constantly narrowing the limits of the class which occupies the lowest step in the progress of society. This mission alone stamps the system as an active element in the moral elevation of the race. The factory system does not tend to intellectual degeneracy."

The arguments thus far adduced have all been one-sided in showing that an increase in civilization and in refinement follows an increase in wealth. There is another side to the question. A portion of the laboring masses are dissatisfied. This side is ably treated in this month's issue of the *North American Review*, by Rev. J. S. Zahm, C. S. C., entitled 'Leo XIII. and the Social Question.' I quote as follows:

"In lieu of the old organic regime the French Revolution substituted the reign of individualism. Unlimited competition, freedom of labor, the preponderance of capital and the general introduction of machinery ushered into existence the fourth estate proletarians, or wage-earners—and with it the social question. The organism became a mechanism, and from its excesses proceeded the evils from which we now suffer. As matters at present stand, we have two inimical forces, standing face to face; on one side, the modern state, with its army and its police; on the other, socialism and organized labor with its battalions and its long pent-up grievances.

"Never before was humanity confronted with such a danger. Three centuries of renaissance of pagan law and a century of *laissez-faire* and *laissez-passer* have atomized society and divided the human family into two opposing camps—on one side the tyranny of the law and of the employer; on the other, renewed servitude and virtual rebellion—everywhere hatred, lack of equilibrium, egotism and overt struggle.

"Formerly after the struggle between employer and employee was over, rest and peace were to be found in the workshop or in the home, whereas to-day the struggle has reached our very hearthstones. It persists in a dull and sullen manner, when it does not break forth openly, and it is ever compassing the ruin of society because it is incessantly destroying all chance of domestic happiness. Never before, indeed, has the social question knocked in so threatening a manner at the doors of the civil order."

Mr. Zahm charges machinery, which is engineering, with being one of the chief causes of social troubles. He says further:

"It may truly be said that the social question arises from a five-fold revolution: the revolution in machinery; the revolution in political economy; the revolution in religion; the revolution in the state, and the revolution brought about by the general movement of humanity.

"Machinery, or rather the abuse of machinery, was the first to effect a transformation in the economic order. It is not without reason that Lasalle styles it 'the revolution incarnate'—*Die verkoerperte Revo-*

lution. Machinery has revolutionized the mode of production, the manner of labor, and the distribution of revenue and of property. It has destroyed the workshop and introduced the factory in its stead. It has sterilized manual labor, and, by its immense productivity, has internationalized prices and markets. While, on the one hand, it has created the despotism of capital, it has, on the other, called into existence the unorganized army of the proletariate. It has ground humanity into a powder, without cohesion and without unity, and has placed the world of labor at the mercy of a few soulless plutocrats. This new order of things means the reign of the few; it implies the permanence of expropriation and the resurrection of ancient Rome, where millions of slaves were trampled under foot by an insolent oligarchy of wealth. And finally, by its fatal centralization machinery has engendered a double International—the International of capital and the International of socialism. Never has a more complicated situation, or one more pregnant with peril, weighed upon men. What were the invasions of the barbarians from the north of Europe, or the upheavals of the fifteenth and eighteenth centuries, in comparison with the threatened explosion of this vast world already stirred to its profoundest depths and in a state of violent ebullition?"

The remedy for this terrible state of affairs, according to Mr. Zahm, is to be found in following the advice given in the recent encyclical letter of the Pope. I quote.

"In the introduction to his epoch-making document, Leo XIII. directs attention to some of the evidences of the dominant evil, extreme riches, extreme misery, and the indescribable desolation which has entered the world of the proletariate in consequence of the atomization of society under the leveling reign of capital.

"As in the politico-religious order, Leo XIII. has, through his encyclical '*Immortale Dei*,' preached the code of reconciliation, so has he, in the economic order, promulgated the character of social harmony. For the first time economic science has pity on the wage-earner, and discusses the new issues raised without rancor or recrimination. At the same time it exhibits a respect for the rights of all while insisting on the duties of all, which will forever render the encyclical, '*Rerum Novarum*,' not only the most glorious monument of the present pontificate, but also the most beneficent contribution yet made to the new order of things."

We must give all honor to Pope Leo XIII. for his earnest efforts to bring about social harmony, but Mr. Zahm is surely not right in saying that this is the first time that economic science has pity for the wage-earner. Many writers in all schools—Henry George, for example—have been animated by sincere sympathy for the wage-earner, and have earnestly discussed means of ameliorating his condition. I hope to show in my conclusion that the whole tendency of economic evolution is toward bettering the condition of the wage-earner.

Mr. Hewitt in his Presidential address before the American Institute of Mining Engineers in 1890, entitled 'Iron and Labor,' 'Trans. A. I. M. E.' Vol. XIX., pp. 496, 497, speaks of 'the new era,' when every intelligent workman will insist on being an owner, and every well-managed corporation will see that its workmen are directly interested in the results of the business. He says: "The time is approaching when capitalists and laborers will more and more be joint owners in the instruments of production. While the wages system will necessarily survive, the workmen will, to a large extent, become their own employers, and finally may hire capital as capital now hires labor. The facilities offered for the division of prop-

erty, through the distribution of corporate shares, will lessen strife, develop skill, reduce cost, increase production and promote the equitable distribution of wealth, which, it must never be forgotten, is the chief end of the social organization."

The equitable distribution of wealth which Mr. Hewitt speaks of is the aim of all honest political economists of all schools. They only differ as to the means through which it is to be brought about, and they differ vastly in their apprehension of what is the existing state of things. The chief difficulty of the socialist writers and such men as Henry George and Mr. Zahm is that they do not see clearly the existing facts. Seeing the vast wealth of a few individuals, they preach the dictum the 'rich are growing richer and the poor are growing poorer,' the last half of which is a stupendous economic falsehood, equalled only by the dictum of the anarchists that 'property is robbery.' Innumerable facts can be adduced to show that the statement that the poor are growing poorer is a falsehood. Statistics prove beyond all question that in all the civilized world the wages of labor have tended, ever since the extensive use of the steam engine, say, since 1850, to increase, and the cost of living to decrease. Statistics of savings banks, of building associations, of life insurance companies, of fraternal assessment life insurance associations, of the ownership of small houses and small farms, of the reduction of mortgages on farms, all show that not only is there a vast increase in the wealth of the Nation as a whole, but that this wealth is being more widely distributed than ever before. A magazine article recently said that more than one-half of the entire population of New England, including men, women and children, are depositors in the savings banks, the average amount to the credit of a depositor being $363. It says of the depositors: "If it were possible to prove what is apparent to the eye of any one who watches the customers of these banks, it would be found that very much the largest part of them are the women and children. The aggregate deposits in the savings banks in New England is $774,000,000. In New York State alone it is $644,000,000.". In the little town in which I live, Passaic, N. J., containing 18,000 inhabitants, a considerable part of the popnlation are Poles, Bohemians, Hungarians and other natives of southern Europe. They are recent immigrants, working in mills; yet one of the two savings banks in the city has 2,500 depositors, the deposits amounting to nearly $400,000; and in addition these same foreigners last year sent to Europe, in the shape of drafts issued by this same bank, not less than $50,000.

Place the statements just made concerning savings banks against those made by Mr. Zahm—viz., that the human family is divided into two opposing camps; that we have two inimical forces standing face to face: on one side the modern State with its army and its police; on the other socialism and organized labor. How can we reconcile these two apparently conflicting views of the existing status? Why, very easily. Mr. Zahm's two opposing camps exist: on one side the socialists, on the other side the police; but his eyes were blinded when he said that the whole human family is divided into two opposing camps. He failed to see the vast majority of the people who belong to neither one camp nor the other, who are the savings bank depositors, the owners of small homes, albeit with small mortgages on them, who are members of building associations and fraternal life insurance societies. The grandest fact in the economic history of this age is the great increase in the number of the people in comfortable circumstances who once were numbered among the poor. The increase in the middle class goes along with a great decrease in the

number of the very poor. The poor are growing poorer, say the agitators. Whom do you mean by the poor? Is it a family that has only $100 in the savings banks? Next year it will have $200 and five years thence $1,000.

Do you mean, then, we ask the agitator, the man who has not a dollar in any bank, who has not enough ahead to keep him from starvation a week? If he is the man whom you call poor, and whom you have been saying for the last 20 years that he is growing poorer, how much poorer is he going to get? How many such men are there in the United States? Let them stand up and be counted.

We have seen that engineering is the chief factor in the production of wealth; that wealth has enormously increased in the past few years, and that it is being well distributed, although perhaps not as well as it ought to be, among the common people. What of the future? Engineering has caused men to leave the farm and seek the cities, because in the cities they can grow rich faster. Engineering, again, through rapid transit, electric cars and the like, is making it possible for these men who work in the city to sleep in the suburbs, and bring up their families in a place which has all the advantages of city and country combined. One of the triumphs of the iron-making engineer has been the construction of a hollow steel tube of great lightness and strength. The mechanical engineer has found out how to make ball bearings, and lo! we have the bicycle of 1895, 400,000 of them to be made in this year. Who can estimate the value to the people of this new industry, building up an athletic and healthy race of men and women, and causing good roads to be built from one end of the country to the other, another work of engineering by which the farmer may move his crops more cheaply and the cost of food be correspondingly decreased. What next? As Mr. Hewitt has foreseen, the wage-earner will become a stockholder in the corporations for which he works, and labor will hire capital, instead of capital hiring labor. Then what Mr. Zahm calls the fourth estate, the proletariat, will cease to exist. It will be merged into the third estate, the common people, who are at the same time wage-earners and capitalists. The proletariat, or fourth estate, as a separate element in society, antagonistic to the third estate, is already a vanishing quantity. We who are old enough remember the alarm created throughout the world in the years 1867, 1868 and 1869 when the dreaded 'International' held its congresses in Europe. Who now dreads the International. True, it may be strong enough some day in some one or more places to repeat the terror of the Paris Commune in 1871, but the uprising will end as the uprising of the Commune did, and it will not take two months to end it, as it then did.

"The Empire is peace," said Napoleon III. just before the Franco-Prussian War. He was mistaken. The war took place, causing vast loss and suffering, followed by the terrible agony of the Commune. But how nobly France recovered from the shock, how quickly she paid the indemnity to Germany out of the actual stored savings of her common people. No revolution in the social order took place, only a change in government, then everything went on as before. So it will be if the International should arise, as is predicted by the alarmists, and reproduce the horrors of the French Revolution. The world will live through it; the social order, as of old, will be restored, and the present relations of capital and labor will not be changed, except as by gradual and necessary evolution, due to engineering more largely than to any other one cause, capital and labor becoming merged by the laborers becoming capitalists. This will be the crowning triumph of engineering,

through which the increase of wealth is caused, which enables the laborer to become a capitalist. Then the political economists may meet together and discuss the improved social order, burn their old books, and erect a monument to the man who above all others contributed the means for obtaining the wealth of nations, James Watt, the engineer. William Kent.

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*JOHN ADAM RYDER.**

In 1875, exactly one score of years ago, John A. Ryder began his work at the Academy. Six of these years were spent in the service of the government. The remaining fourteen were in close communion with these halls. The museum and library were the scenes of his many labors.

At one time his friends feared that he was covering too large a field. Doubtless, the fear would have been sustained if Ryder had pursued his studies along conventional lines. But we must not judge him by such a standard. His mental attitude was well poised. The objects that 'swam into his ken' came from a wide space. So long as he was searching for the results of vital forces on the economy, it mattered little to him whether it was the teeth of mammals, the tails or scales of fishes, or the movements of protoplasm in a rhizopod that illustrated these actions.

While arranging the collections of the Academy as a Jessup Fund student he found material for his studies in teeth of quadrupeds; while on excursions in the city park, in the smaller articulated animals feeding on fungi or swimming in pools; while on the Fish Commission, in the oyster and its parasites and the movements of fishes; as professor of histology and embryology at the University, in the preparation of specimens for courses of instruction.

What were the mental forces that operated in Ryder to make him what he was? This is of interest, for the result of comparative studies is to aid us in knowing ourselves. How strange is the phenomenon! First, a young student coming to the Academy so absolutely unknown that his first application to a position on the Jessup Fund was deferred. Second, his obtaining the position and setting to work on the collection, rearranging and cleansing specimens, refilling jars and cataloguing. Third, after a career of four years attracting the attention of Professor Baird and leaving the city to accept an appointment on the Fish Commission. Fourth, returning to Philadelphia in 1887 and again in frequenting the Academy, no longer working on its collections, but consulting its library and speaking at its meetings as a University professor. So we find Ryder at the beginning and at the end of his career part of the Academy. But where, in this chain of circumstances, do we find the factors which gave to Ryder those things which distinguish him? Almost precisely the same conditions (so far as the Academy and the University were concerned) were met with in Leidy. Yet how different were the two men! Indeed, so little did Leidy understand Ryder that he endeavored (with the most kindly motive) to dissuade him him from a career of study. Leidy knew that men who are dependent on science for a livelihood secure fewer prizes in the struggle for maintenace than do those in any other learned calling. This statement is yet true, and it had special force twenty years ago.

Thus while the Academy gave Ryder incalculable aid (the soil, indeed, in which he grew), the influences which determined the character of his work were extraneous. These were in brief the influences of the

* *An address on 'Dr. Ryder's relations to the Academy of Natural Sciences;' of Philadelphia, by Dr. Harrison Allen, given at the memorial meeting on April 10, 1895, and published by the committee in charge of publication.