on spectroscopic analysis with most brilliant results. Langley's classic results with the bolometer in the in visible infra-red spectrum being worthy of citation as an example of the requirements of modern physical tests. In the same line Michelson worked in the obtaining of a scientific unit of length by using the wave length of specified light, and this is a wonderful illustration of the refinement of physical methods. The old time distinction of vapor and permanent gas has ceased to exist, as all the gases have yielded to the experimenter and have been liquefied, and, in many cases, solidified. Crookes discovering peculiar phenomena in gases at very high degrees of exhaustion endeavored to prove the existence of a fourth state of matter, adding one to the long accepted division. While his researches have not definitely established this fact, they have led the way to the most recent of the discoveries of physics, "last of all the greatest," the X ray phenomenon discovered by Roentgen, a name that will go down to posterity with that of Newton, Faraday and Maxwell.

MEN OF PROGRESS.

On the opposite page we present a reproduction of the large engraving, "Men of Progress—American Inventors," a fine steel engraving which was published by Munn & Company. The original oil painting from which the engraving was made was painted by C. Schussele in Philadelphia, in 1861. It was engraved on steel by John Sartain, a Nestor of American engravers. It is a fine example of the perfection to which steel engraving has been brought at the period in which it attained its highest development. In thousands of homes to-day this superb engraving still ornaments the walls.

On the left of the engraving is Dr. Morton (1819–1868), a dentist, who first used ether as an anæsthetic in 1846. From this dates the introduction into surgery of ethereal anæsthesia; next to him is James Bogardus (1800–1874), whose numerous inventions include a ring spinner, an engraving machine and the first dry gas meter. He was also interested in building iron buildings, and was one of the fathers of the modern system of iron construction. Col. Colt (1814–1862), the inventor of the Colt revolver, who is next to him, is referred to elsewhere in the more extended biographical notices, as is also Cyrus McCormick, the father of the reaper, who is at his right. Behind is Joseph Saxton (1799–1873), who devised ingenious mint machinery and coast survey and meteorological instruments.

Charles Goodyear (1800–1860), who is seated at the table, immortalized himself as the inventor of the process of vulcanization of rubber, which he patented in 1844. Behind him stands Peter Cooper (1791–1883), who is widely known for his varied talents and many inventions and for the success he met with in the development of the glue industry in this country. He was interested also in various iron works which he successfully exploited. His name will always be remembered as a philanthropist, for he founded and endowed Cooper Union in New York. Seated at the table is Jordan L. Mott, who will be remembered for his works in iron, fuel, etc. Leaning on one side of the pillar is Prof. Joseph Henry (1797–1878). He was an American physicist, especially noted for his investigations in electro-magnetism. On the right of the center is Dr. Eliphalet Nott, who made important researches on the management of heat. Behind is Capt. John Ericsson, of whom a more extended account is given on another page. In front is Sickles, who invented a steam cut-off. Seated in a chair is Prof. Morse, who is perhaps the most imposing figure in this unique collection of American inventors. His portrait and a biographical sketch may be found in another page. Behind is Henry Burden (1791–1871), a Scotch-American inventor. His inventions include a cultivator (1820), the hook-headed railroad spike, and a machine for making horseshoes. This machine produced from the iron bars sixty horseshoes per minute. In 1833 he built a cigar-shaped steamboat 300 feet long, which was afterward lost.

Richard Hoe, who is at the left of Morse (1812–1886), perfected, in 1846, a rotary printing press, which received the name of Hoe's lightning press, and he subsequently invented the Hoe web perfecting press. These inventions are described on another page. Next to him is Erastus Brigham Bigelow, who will be remembered for his inventions in relation to the carpet loom. In 1838 he patented a remarkable loom for weaving knotted counterpanes. In front of him is Jennings, who made important discoveries and inventions regarding the manufacture of matches. Thomas Blanchard (1788–1864), is chiefly known for his eccentric lathe for turning irregular forms, such as lasts, spokes, gunstocks, etc. He also invented a tack machine in 1806, and a steam carriage in 1825; he also built a stern-wheel boat for shallow waters, which is now largely in use in Western rivers. Howe, on the extreme right, is referred to in the article on the sewing machine and also in the brief biographical note which will be found on another page. The group is one of extreme interest as representing those inventors who were especially distinguished about the time of the breaking out of the civil war. It is to be hoped that some artist will come forward and portray the inventors of the last decade of the nineteenth century as faithfully as has the painter of these "Men of Progress."

THE TEXTILE INDUSTRIES OF THE UNITED STATES SINCE 1846.

Modern methods of textile manufacturing had their beginning in the forties, or about fifty years ago. The inventions that have contributed to make the textile industry in the United States what it is to-day first made their appearance at about that time. The modern system of textile manufacturing, therefore, has had an existence of almost exactly half a century. Before then, the various processes of manufacturing were in a sort of transitory or equivocal state of existence—inharmonious one with another. For a hundred years a struggle had been going on for the establishment of an equilibrium between them, which was not fully effected and realized till 1851, when systems, mechanical methods and comparative perfection of product became known to the world at the London international exhibition. The manufacturing world then, for the first time, became cognizant of the fact that there was before it the beginning of a new era of existence. American and foreign inventions had brought about this improved condition of affairs. The great inventions of the eighteenth century had served their purpose and been superseded by those that allowed more continuous and automatic operations. The spinning mule had been made successfully self-acting; the jenny had been thrown aside, while its coadjutor, the billy, was made to serve a new purpose in wool spinning as a more important auxiliary to the carding machine; and the latter for wool had been modified and new devices attached to it for the purpose of simplifying processes and improving the quality of work done. The cotton manufacturing industry had attained development or made more rapid progress to maturity than had been the case with the woolen industry. But at that period both, it may be said, began a new life, regenerated, and started upon their present career. The Crompton fancy cassimere loom, which first appeared in the forties, and John Goulding's inventions affecting carding and spinning, which began to be appreciated at that time, did more to modernize the woolen industry than anything else. The worsted industry, as it is known to-day, had its beginning at that period in the perfection of the combing machine, more, however, as an English than an American industry, the latter appearing later. The silk manufacturing industry, also, began about this time with its centralizing at Paterson, N. J.

At the beginning of the 1850–60 decade, the three textile industries that will be considered in this article, cotton, woolen and silk, were well established, and have remained important factors in the industrial development of the country. Their relative growth may be seen in the following census statistics showing the comparative value of products:

	Cotton.	Per cent.	Woolen.	Per cent.	Silk.	Per cent.
1850	$61,869,184	54·6	$49,636,881	43·8	$1,809,476	1·6
1860	115,681,774	57·0	80,734,606	40·0	6,607,771	3·0
1870	177,489,739	43·6	217,668,826	53·4	12,210,662	3·0
1880	192,090,110	38·4	267,252,913	53·4	41,073,045	8·2
1890	267,981,724	38·7	337,768,524	48·8	87,298,454	12·5

As will be observed, measured by the value of their products, the cotton manufacturing industry was preeminent over that of wool in 1850 and 1860, but occupied second place in 1870, 1880 and 1890. Abnormal conditions existed in the sixties, favorable to the woolen and detrimental to the cotton industry, giving the former an impetus that put it first in rank, which it has since retained, though its relative position has been somewhat diminished since 1890, based on the productive capacity of machinery, product values not being obtainable. Since 1890 the productive capacity of the cotton manufacturing industry has increased about 13 per cent, while that of the wool manufacturing industry has increased only about 8 per cent. There is no doubt, however, that the woolen industry still holds its first position in the textile line in the value of products. The silk industry has been steadily gaining, as will be seen, since 1850, till it occupies a relative position of no mean proportions.

The silk manufacturing industry of the United States, in the diversity and excellence of its product, has made commendable progress within the last forty, and even ten or fifteen years. The Chicago Exposition of 1893 revealed an elegance of American silk manufacture that the general public scarcely dreamed of as having an existence. In 1850 the silk manufacturers of this country were confined almost wholly to sewing silk, and no marked progress was made till after 1870, when, by the census of 1880, it was seen that considerable advances had been made in the manufacture of dress goods, which by 1890 became of the first importance with that of ribbons. In color, design and finish, American silk dress goods compare favorably to-day with the best made abroad. The silk industry is chiefly (91 per cent) confined to the four States of New Jersey, New York, Pennsylvania and Connecticut, centralized in certain localities, Paterson, N. J., being first in importance. The status of the silk industry in the United States may be seen from the following statistics, taken from the 1890 census:

VALUE OF PRODUCTS.

United States, gross value				$87,298,454
New Jersey,	Paterson	$22,058,624		
	Elsewhere	8,701,747	$30,760,371	
New York,	New York City	13,579,462		
	Elsewhere	5,838,334	19,417,796	
Pennsylvania,	Philadelphia	8,059,604		
	Elsewhere	11,297,942	19,357,546	
Connecticut			9,788,951	79,324,664
In other States				$7,973,790

The silk industry is centered chiefly about Paterson, New York and Philadelphia. Not far from 60 per cent of it is so situated.

Industries.	Capital.					Live Assets.	Value of Products.
	Aggregate.	Value of Plant.					
		Total.	Land.	Buildings.	Machinery, Tools, and Implements.		
Lumber and other mill products from logs and bolts	$496,339,968	$294,325,888	$156,539,097	$31,273,534	$106,513,257	$202,014,080	$403,667,575
Iron and steel	373,478,018	210,830,316	31,553,087	42,766,656	136,510,573	162,647,702	430,954,348
Cotton goods	354,020,843	230,993,567	23,225,097	69,742,664	138,025,806	123,027,276	267,981,724
Woolen goods	$130,989,940	$57,820,243	$6,534,819	$19,332,575	$31,952,847	$73,169,697	$133,577,977
Worsted goods	68,085,116	27,890,810	2,842,769	7,962,865	17,085,176	41,194,306	79,194,652
Carpets	38,208,842	17,375,384	2,884,139	5,559,458	8,931,787	20,833,458	47,770,193
Felts	4,460,621	1,865,984	276,780	714,453	874,751	2,594,637	4,654,768
Wool hats	4,142,224	1,194,389	144,350	381,105	668,934	2,947,835	5,329,921
Hosiery and knit goods	50,607,738	23,574,761	2,271,466	6,194,088	15,109,207	27,032,977	67,241,013
Total	$296,494,481	$129,721,571	$14,954,323	$40,144,544	$74,622,704	$166,772,910	$337,768,524

The relative status of the cotton and woolen industries, as it existed in 1890, and which is preserved to-day, or nearly so, may be seen in the foregoing table. The four leading manufacturing industries of the United States are here given, the lumber manufacturing interest holding the commanding position in the amount of capital employed, without including planing mill products and the more advanced articles of wood manufacture. Iron and steel rank next, without including anything manufactured therefrom. The manufacture of cotton goods occupies the third, and of woolens, the fourth position. In the value of products the relative positions are somewhat changed. But taking the two great textile industries—cotton and woolen—together, and, in amount of capital and value of products, they stand supreme over all others. Taking all the six New England States together, where these manufactures mainly exist, 34 per cent of the capital invested in all kinds of manufactures is represented in the cotton (21 per cent) and wool (13 per cent) manufacturing industries. The importance of these industries to that section are thus seen, and the effect their prosperity has upon the communities in which they are located.

The cotton manufactures of the United States, as noted above, advanced in the value of their products from $62,000,000 in 1850 to $268,000,000 in 1890, or 332 per cent. In number of spinning spindles the advance was from 3,600,000 to 14,200,000, or about 300 per cent. The increase in value of product and in number of spindles was about the same for this period. The number of spindles in 1846 was about 2,400,000; in 1895 it was 16,100,000, an increase of 570 per cent, and the annual consumption of cotton, per spindle, was 73·4 and 80·5 pounds respectively. The consumption, per spindle, it would thus appear, has increased but slightly within the past fifty years. But important factors have to be considered in this connection; as consumption per spindle is, after all, no more than a statistical curiosity, meaning much or little, according as it is used. Speed of spindle and count of yarn must be taken into calculation. The productive capacity of a spindle to-day is about 44 per cent greater (some are inclined to put it more) than it was fifty years ago, so that measured by this standard the cotton manufacturing industry has advanced within the past fifty years not 570 per cent, but 866 per cent. That this is not shown in the consumption of cotton is due to two causes: less running time and finer counts.

The progress that has been made in the mechanical

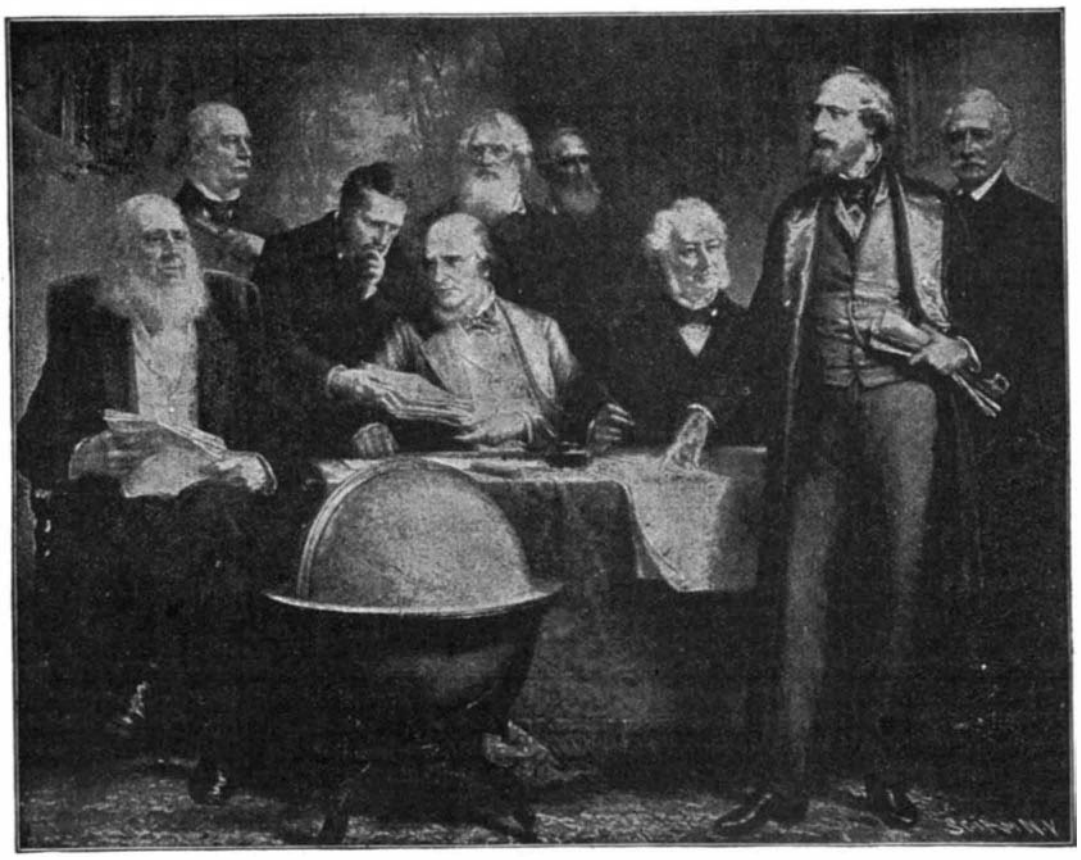
processes of cotton manufacturing is gaged more satisfactorily by the advance that has been made in the improvements in spinning on the ring frame. This machine is peculiarly an American invention, while the mule is not. In 1890, 63 per cent of the number of spindles in the United States belonged to this machine. It asserted its value to manufacturers before 1850, but little was done to it or any machine used in cotton manufacturing till after the late war, more than in perfecting details. In this latter respect, however, the progress was marked, so that by 1865 all the mechanical processes had been brought to a high standard of efficiency, equal, if not superior, to anything of like character observed in other branches of the textile industry. Even since the war the perfecting idea has chiefly engaged the time and attention of machine builders, though of late years the introduction of what is known as the revolving flat card (an English invention), and more particularly the Northrop automatic loom, has given cotton manufacturing a new impetus of great significance.

In the spinning frame the productive capacity and progressive steps of a cotton factory are distinctly noted. The machine has not till quite recently been brought to a sufficiently high state of perfection for spinning fine counts of yarn to bring it into competition with the mule, and especially so in the spinning of fine weft. A very recent invention gives great promise of overcoming difficulties of this kind, and within a few months it has been put into practical operation in one of the fine yarn mills of New England upon weft as fine as number 110, which to a manufacturer means a tremendous advance in this method of spinning, and which to him has much greater significance when it is stated that this weft yarn has all the characteristics of mule yarn, with the front or delivery rolls of the machine speeded at 84 turns per minute and the spindles putting in 28·92 twists per inch. This is probably the greatest advanced step taken in cotton manufacturing within the last quarter of a century or more, with the exception of that in weaving by the Northrop loom, which is a wonderful product of American ingenuity and persistent enterprise. This loom ranks with the self-acting mule and the Crompton fancy cassimere loom as the grandest invention in the textile machinery line within the present century. It is epoch making.

The tendency of cotton manufacturing in the New England States is toward finer yarns and goods, more than what is indicated in the consumption of long-stapled cotton of domestic Sea Island and foreign growth. Still, the latter furnishes the only means of estimating it. The consumption of this kind of cotton is nearly 60,000,000 pounds to-day to less than 16,000,000 pounds seven years ago, when fine spinning by Northern mills received a new vitality due to the competition of Southern mills which had become particularly sharp on coarse yarn spinning. To-day, about six per cent of the consumption of Northern mills consists of long-stapled cotton for specially fine yarns, while in 1889 and 1890 this consumption was somewhat less than two per cent. The progress toward the spinning of extra fine yarns is evident, yet it cannot be said that American mills are more than at the beginning of an era of fine yarn spinning.

The wool manufacturing industry of the United States has always been one of particular solicitude for legislators and others. Wool growing and wool manufacturing have for the last thirty years been mutually supporting in a legislative way. Within the last fifty years the wool manufacturing industry has expanded from an annual product of about $50,000,000, in 1850, to nearly $338,000,000, in 1890. In the forties, and for many years thereafter, the woolen product of this country was mainly broadcloths, flannels and satinets, all honest goods to the extent of using pure wool, very little shoddy or wool substitutes being employed till after 1860, when the practice of using adulterants was largely indulged in, with many examples of creditable success so far as skill in deceptive manufacture was concerned. The tendency toward larger factories and concentration of capital is noted in the census of 1860, which gave 1,476 establishments capitalized at an average of $26,300 per establishment, compared with an average of $145,000, as given in the census of 1890. The changes and progress in the woolen industry may be epitomized thus: plain goods of pure wool, as broadcloths, satinets and flannels, with a tendency to fancy cassimeres, from 1845 to 1860; fancy cassimeres and flannels, with a tendency to worsted fabrics for men's and women's wear, from 1860 to 1880; and since 1880, worsted fabrics for men's and women's wear, with no particular tendency away from these fabrics, all energy being devoted toward their perfection and attractiveness. These changes have been brought about by the mechanical inventions which have made these manufactures possible in a manner that appealed to the taste of the fashionable world. The chief mechanical factors in these changes were the loom and the comb, now brought to a remarkably high state of efficiency. There is probably a third more worsted fabrics made now than in 1890. It is the combing machine, for wool and cotton, that is to act the chief part in determining the character of American textile manufactures for the next ten years or more. It is only within the last fifteen years that any conspicuous advance has been made in combing comparatively short-stapled wool like the merino. The introduction of a class of machinery capable of effecting this has revolutionized the wool manufacturing industry of this country. The value of the worsted manufactures of our mills has increased from $3,701,378 in 1860, per annum, to over $100,000,000, in 1895.

The manufacture of knit goods has increased rapidly within the last few years, of which there are no official statistics, in line with the progress made during the decade of 1880-90, within which period there was an advance in the value of products of 131 per cent, exceeding that of any previous decade. Before 1850, the knitting industry was of small concern, not large enough to excite more than local interest.



David Dudley Field. S. F. B. Morse. Daniel Huntington. Cyrus W. Field. Wilson G. Hunt.
Peter Cooper. Chandler White. Marshall O. Roberts. Moses Taylor.

PROJECTORS OF THE TRANSATLANTIC CABLE.

THE SUBMARINE CABLE.

The history of telegraphy gives an early date to the first conception of a submarine cable, as many of the earliest experiments in telegraphic transmission were made under water with an insulated wire. Morse's experiments of 1842 between Governor's Island and the Battery in New York gave him a basis for his prediction that the Atlantic would yet be crossed by a telegraph cable. In 1845, Ezra Cornell, who, we have seen, is identified with the early progress of the telegraph, laid a cable across the Hudson from Fort Lee to the city of New York, which did good service for a year, when it was destroyed by ice. In Europe, the first genuine submarine cable dates back to 1850, when a gutta percha covered copper wire was laid between Dover and Calais, which lived only a single day, friction against the rocks destroying its insulation. Another one was laid in 1851. This new one was armored with ten galvanized iron wires and operated for many years successfully. Two years later Dover and Ostend were connected.

It now became evident that the time was approaching for carrying out Morse's prophecy. Mr. Brett, of England, had been identified with the Dover-Calais cable. Mr. Cyrus W. Field and other capitalists with Mr. Brett organized a company in 1854, and Mr. Field obtained a franchise from the provincial government for fifty years for landing transatlantic cables in Newfoundland. In 1856 soundings were made between Ireland and Newfoundland, and after several attempts a successful cable was laid between Nova Scotia and Newfoundland. The first attempt at spanning the ocean began on the 7th of August, 1857, when the English ship Agamemnon and the American ship Niagara laying a cable started from Valentia, Ireland, and directed their course for St. Johns, Newfoundland. The cable broke on the third day. A second attempt was made in 1858. This time the work of laying the cable was commenced in mid-ocean, the ships separating and proceeding shoreward, one to the east and one to the west, each laying cable as they separated. Two failures in the cable caused the abandonment of this expedition when about three hundred miles, at the most, of cable had been laid. Again the effort was made, and on the 5th of August, 1858, the third attempt ended, the laying was successfully accomplished, and Cyrus W. Field sent his first telegram across the ocean from America to Ireland on the 7th of August of that year. The insulation soon began to fail, and on the 1st of September the cable broke down entirely. Oliver Wendell Holmes' poem on the subject of De Sauty, the electrician of the company, with his message, "All right, De Sauty," as its refrain, will be recalled in connection with this breaking down of the thin strand on which so many hopes depended.

Between August 13 and September 1, 1858, 129 messages of 1,474 words were sent westward, and 271 messages of 2,885 words were sent eastward, when the cable failed. A message from Queen Victoria to the President of the United States, 99 words long, required 67 minutes for its transmission. Endless trouble was experienced in operating the cable before it ceased to work at all, and up to December 1, 1858, the company had expended $1,834,500 in its failure. The interval that elapsed between this and the successful laying of the next cable was due largely to the civil war, but during the twelve years from 1854 to 1866 Mr. Field never abandoned the subject, and crossed the ocean some fifty times, largely in the prosecution of the plan.

A new company was formed in 1866. A second cable had been laid part way across the ocean and abandoned the year previous, breaking after 1,200 miles were laid. The new company started a new line across the ocean and intended to pick up the abandoned cable and put that to work also. The line was commenced in Ireland, on the 13th of July, 1866, and was finished on the 27th of the same month, and on the 4th of August, 1866, the Atlantic cable was declared open to the public.

The other cable was grappled for and recovered, and it was completed, thus giving two lines between the continents. Cyrus W. Field received great renown from his work. The United States Congress voted him a gold medal, the Paris Exposition of 1867 gave him a gold medal, and he would have received high honors in England, it is said, had he not been a citizen of another country.

The Great Eastern, the most monumental failure in the history of steam navigation, seemed for a time to have found a scope for her abilities in the laying of transatlantic cables, but since her time many special cable ships have been built, with every appliance for successful and cheap prosecution of the work of laying cables, and the Great Eastern has been broken up for old iron. The cable is payed out over the stern of the ship through special apparatus by which any desired strain can be put upon it. The theory is that it has to be laid upon the bottom, no suspension from summit to summit of subaqueous ridges being permissible. Hence it has to be fed out at varying strain and rate according to the slope of the bottom on which it is being deposited. The work has become wonderfully systematized. Cables are laid at sea with the same unconcern that attends any ordinary voyage in a well equipped ship under favorable conditions. The system of buoying the ends of cables has become so perfected that a ship now has no hesitation in dropping the end of the cable, to be picked up at any time convenient in the future. Nevertheless, the early struggles in the laying of the cables form most impressive lessons in the ability of mankind to overcome obstacles.

After the failure of the first European-American cable, a new route was agitated from Labrador to Scotland, by way of Greenland, Iceland and the Faroe Islands. This route is about 1,800 miles long, and the