that Harveyized steel plates are the best in the world. The construction of battleships has been modified by the introduction of Harveyized armor, and the new process is being adopted by the principal manufacturers of Europe. Mr. Harvey, in the course of a long and eventful life, had 125 patents granted to him.

Samuel Colt, whose name will ever be identified with the production of the revolver, was born at Hartford, Conn., in 1814, and died there in 1862. In his fourteenth year he ran away from school and went to sea. While on his East India voyage he made a model in wood of a revolving pistol. This was the germ of the great invention. After his return from Calcutta, he studied chemistry in the dye house of his father, and afterward traveled extensively in the United States and Canada, giving lectures on chemistry. He thus gained the means necessary to prosecute his invention of the revolver. In 1835 he visited England and France, taking out patents, and on his return he took out his United States patents. He established a factory at Paterson for the manufacture of his arms. There was, however, little demand for the new weapon, and the company became insolvent. During the Mexican war, in 1847, the manufacture of the revolvers was resumed—first at Whitneyville, Conn., and finally at Hartford. This last establishment was built on a very large scale, and made not only revolvers, but machinery for constructing the same, cartridges, etc. Mr. Colt also invented a submarine battery for the defense of harbors, and also a method of insulating submarine cables. In 1843 he laid a cable from Coney and Fire Islands to the city of New York, which was operated with success.

George Henry Corliss was born at Easton, New York, in 1817, and died in Providence, R. I., in 1888. He attended school until he was fourteen, and then became a clerk in a cotton factory; later he spent three years in Castleton Academy, Vt., and finally opened a country store at Greenwich, N. Y. He early showed a leaning toward mechanical pursuits, and in 1844 he moved to Providence, R. I., where, in 1846, he began to make improvements in steam engines. He patented what is now universally known as the "Corliss" engine in 1849. These improvements have revolutionized the construction of the steam engine. By the new devices the governor was connected with the cut-off, preventing waste of steam, and insured uniform speed under the most varying loads. A company was formed in 1856, and they adopted the novel plan of taking the saving in fuel for a given time as their pay. The large Corliss engine was one of the wonders of the Centennial Exposition, and is still in use, driving one of the largest manufacturing plants in the country. Mr. Corliss received many honors and decorations, and amassed a large fortune. He made many other minor inventions.

Thomas Alva Edison was born at Milan, Ohio, in 1847. He began life as a train boy, soon advancing to a newsdealer with assistants. He studied telegraphy and obtained a position as operator at Port Huron. He soon became noted for his speed and accuracy, his messages being taken down in handwriting like copperplate. He soon began to invent, and in 1864 he moved to Memphis and had one of his inventions, an automatic repeater, put into service. He struggled along, inventing and working at his profession, until he went to Boston in 1868, where he was able to open a workshop for developing his inventions. Shortly afterward he was retained by the Western Union Telegraph Company, and started an electrical laboratory at Newark, where he employed 300 men. In 1876 he moved to Menlo Park, New Jersey, and in 1887 left Menlo Park and erected in Orange, New Jersey, what is supposed to be the largest experimental laboratory of its kind in the world. His inventions, which are numbered by hundreds, center largely on electricity, although one of the most wonderful of his achievements is the phonograph. They include inventions in duplex and quadruplex telegraphy, the carbon transmitter telephone, the incandescent lamp, the electric railroad, the electrophone, the motograph for accelerating speed in ocean cabling, the microtasimeter, the odoroscope, the megaphone, the phonoplex telegraph, the pyro-magnetic motor and generator, the magnetic bridge, the electric pen, dynamos and motors, the kinetograph, the magnetic ore separator, and last of all the fluoroscope and the new vacuum light. Taken all in all, the inventions, both from quantity and value, place Mr. Edison in the very front ranks of the inventors of all ages, and it is gratifying to note that he has reaped both honors and rich rewards for his discoveries.

Cyrus Hall McCormick, the inventor of the reaping machine, was born at Walnut Grove, Va., in 1809. He died in Chicago, in 1884. His education was obtained in the common schools; he also helped his father in farm work, and at the age of fifteen had constructed a cradle used in harvesting in the field. At the age of twenty-one he invented two new and valuable plows. As far back as 1816 his father made attempts to construct a reaper, but these attempts only ended in failure, but in 1831 young Cyrus proceeded on a new line, and succeeded in making a success of the new grain harvesting machine which was to bring him fame and fortune. He patented his reaper in 1834, and improvements on it in 1845-47 and in 1858. In 1847 he moved to Chicago, where he built a large plant. He received numerous awards for his invention, which also obtained for him a large fortune. He was elected a corresponding member of the French Academy of Sciences, "as having done more for the cause of agriculture than any other living man." It was estimated in 1859 that his invention saved the country at least $55,000,000 per annum. Of course, with the growth of improvement, this sum has been largely augmented.

AMERICAN SHIPBUILDING.

Though the history of American shipbuilding has been marked by many fluctuations, there had never been a time, from the colonial days of the seventeenth century down to the sudden decline of the middle of the nineteenth century, when it had not been in a more or less healthy condition. The records show that fifty years ago we had entered upon the last and most brilliant era of shipbuilding which the country has ever seen. In the three years, 1843 to 1846, the total yearly tonnage built in the United States had risen from 63,888 to 108,203 tons. In 1850, 279,255 tons were built, and in 1855 the total rose to 583,450 tons. So rapid was the growth that by the year 1860 there was a total of 5,353,868 tons in the merchant marine, 2,379,396 tons of which were engaged in the foreign trade. At this time the total tonnage of the British empire was only slightly greater—5,710,968 tons.

It was inevitable that an enterprising country, with a 3,000 mile Atlantic seaboard flanked by great forests of timber that was excellently adapted to shipbuilding, should create a powerful merchant fleet; and the rapid decline which took place at this time is primarily to be ascribed, not to any decadence of the maritime spirit, but to the substitution of iron for wood in the construction of ships; though the collapse was undoubtedly hastened by the outbreak and course of the civil war.

As long as wood was the material of construction the American shipwright more than held his own against the world; but the change from wood to iron came a little too early for the undeveloped condition of the mineral resources of the United States, and we suffered accordingly. In 1855 there were built 381 ships and barks and 126 brigs; in 1870, only 73 ships and barks and 27 brigs; in 1880, but 23 ships and barks and 2 brigs; and in 1895, 1 ship. Of steam vessels we built in 1846 some 46,359 tons; 147,499 tons in 1864, and 69,753 tons in 1895. The above figures, it is true, do not include schooners and sloops, nor the large fleet of canal boats and barges, of which there were 445 built in 1895, with a total tonnage of about 41,000 tons.

In addition to the two causes of decline above mentioned, it must be remembered that the past thirty years has been a period of unparalleled agricultural, mining and manufacturing activity. If the nation has neglected its merchant marine, it has been largely for the reason that it was fully occupied with the development of the internal resources of the country. The discovery of the gold fields of California; the rapid extension of the railroads, and the opening up of the unoccupied farming lands of the West; the development of the mineral wealth of the country, and the rapid growth of the iron industries, have proved a strong counter attraction that has temporarily weaned the heart of the nation away from its old-time love of the sea. Now that the tide of emigration has touched the remotest bounds of the country, and the extent of its resources has been well ascertained, we may look for something of a reaction in the direction of maritime enterprise—indeed, the reaction has already begun.

The teachings of history regarding the relation of the navy to the merchant marine have frequently shown how intimately the interests of the two are associated. A large merchant fleet requires a strong navy for its protection, and a strong navy can never exist without a large merchant marine, from which, in the sudden emergency of war, it can recruit its seamen.

We think that, when the history of American shipbuilding comes to be written, it will be agreed that two of its red letter days occurred on July 23 and 26, 1883, when the celebrated firm of John Roach & Sons, of Chester, Pa., signed the contract for the construction of the Atlanta, the Boston and the Chicago, and the Dolphin, ships which were to prove the forerunners of a completely new and up-to-date navy. The policy which was thus commenced has encouraged our shipbuilders and engineering firms to lay down extensive and costly modern plants, suitable for the building of the most approved modern ships and engines. So utterly stagnant was the shipbuilding industry that it needed some powerful stimulant to arouse it. The prospect of securing contracts for warships, as they shall from time to time be built, has not only encouraged the existing yards to enlarge their plants, but has called others into existence; until to-day we have several firms which are qualified to undertake the construction of the largest merchant steamers, and, as the performance of the St. Paul and St. Louis has clearly shown, to rival the best work of the European builders.

The last census showed that there were in all 1,000 shipbuilding plants in the United States, though, of course, many of these are comparatively insignificant. The important yards are located on the seaboard and on the great lakes, the latter locality having witnessed of late years the growth of a really magnificent steam fleet.

The history of the Pacific fleet dates from the year 1849, when the Union Iron Works had its beginning in a small forge at San Francisco. In 1865 the name of the firm was changed to Prescott Scott & Company, and in 1885, when the fine yard in South San Francisco was opened, the firm became known as the Union Iron Works. This new yard and works is one of the most complete of its kind in the world. The buildings, which are of brick, cover an area of four acres, the total area of the covered works being nine acres. One of the most notable features is the hydraulic dry dock, with an area of 30,450 square feet, which we hope to illustrate in a later issue. The works are underlaid throughout with hydraulic mains, which supply the various lifting, forging, shearing and riveting machines. The Union Iron Works give employment to 1,500 men, and they have turned out some of the most successful ships of the new navy, including the Charleston, San Francisco, Monterey, Olympia and Oregon, in addition to many fine ships for the merchant service. To this firm, aided by the various smaller yards scattered along the coast, must be given the credit of a fleet on the Pacific Ocean which comprises some 1,520 American vessels, aggregating 456,359 tons.

Coming across to the Atlantic seaboard, we should take note in passing of the Iowa Iron Works, Dubuque, Iowa, where the steel torpedo boat Ericsson, of 120 tons and 24 knots speed, was built. There is a world of suggestiveness in the fact that this destructive little craft was built and engined thousands of miles up the Mississippi, and dispatched to the Atlantic by way of New Orleans.

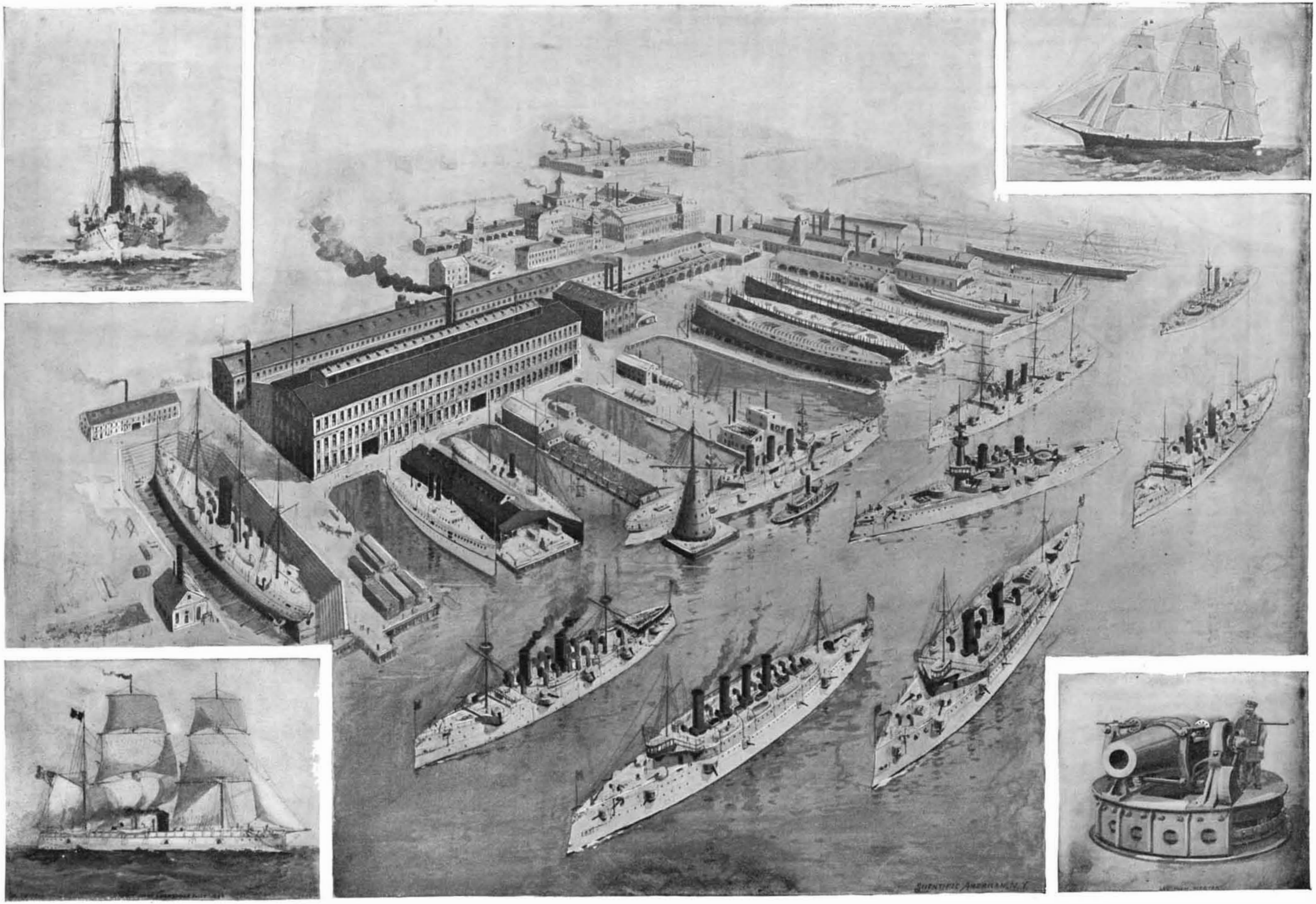
Turning northward to the great lakes, we find that American shipbuilding has advanced by leaps and bounds, and that here, in its inland seas, it has to record a growth of which it may justly be proud. In 1895 our lake shipping comprised 3,342 vessels, with a total tonnage of 1,241,459 tons, two-thirds of this tonnage consisting of steam vessels. The Commissioner of Navigation estimates that the carrying power of this fleet is 2,666,261 tons, in which case our merchant fleet on the lakes alone is larger than that of France, and second only to England and Germany. It only requires a full-sized ship canal to enable the splendid shipyards that fringe the lakes to lend their aid to building up a deep sea fleet that shall be second to none in the world.

Passing on to the New England coast, renowned for its famous yards in the days of the wooden sailing ships, we find a compact and very complete plant at the Bath Iron Works, Bath, Maine. It covers a large area on the banks of the Kennebec River, twelve miles from its mouth. Several vessels for the new navy, including the ram Katahdin, have been launched from its slips. City Point Works, Boston, Mass., and the Herreshoff Manufacturing Company, of Bristol, R. I., have contributed to the list of our merchant and naval fleets, and the latter firm have immortalized themselves in the international yachting world by the production of such craft as Vigilant and Defender. Mention must be made also of the Columbian Iron Works, Baltimore, Md., N. F. Palmer & Company, of Chester, Pa., of Harlan & Hollingsworth, of Wilmington, Del., and many other yards that are contributing to our increasing fleet of deep sea and river craft.

One of the clearest evidences of the faith of American capitalists in the revival of our maritime interests is to be found in the extensive and costly plant of the Newport News Shipbuilding and Dry Dock Company. This concern, like the town from which it is named, has been built up within a very few years. Its extensive shops, dry docks, and building ways have been carefully laid out after a thorough inspection of the great shipbuilding yards of the world. It has turned out some fine ships for the merchant service, and taken an active share in the construction of the new navy, the gunboats Wilmington, Nashville and Helena, which have been constructed in this yard, being just about to be turned over to the government. Here also are being built the Kentucky and Kearsarge, first-class battleships of 11,525 tons, an illustration of which, as they will appear when completed, will be found on another page.

The plant comprises sixteen buildings, which include four shops 100 by 300 feet, and a blacksmith's shop 120 by 208 feet in size. There are four piers ranging from 60 by 350 feet to 60 by 900 feet in size. The plant includes eight ship ways from 400 to 500 feet long, and an outfitting basin 500 feet by 900 feet. There is also a dry dock 600 feet long, with a depth of 25 feet over the sill. Over 3,000 men find employment in the various departments.

There is no shipbuilding concern in America that has contributed so largely to the upbuilding of our modern navy and the merchant marine as the William Cramp & Sons Ship and Engine Building Company, of Philadelphia, Pa. The foundation of this justly famous concern dates from the year 1830, when Mr. William Cramp, then a young man of 23 years, opened a small shipyard at the foot of Otis Street, Philadelphia. That was the age of wood and canvas, and for forty years William Cramp continued to build sailing ships for home and foreign service. In 1871-72 the es-



BIRD'S EYE VIEW OF THE SHIPBUILDING YARD OF WILLIAM CRAMP & SONS, SHOWING WAR VESSELS CONSTRUCTED BY THEM.

tablishment was enlarged to include a water front of about half the length occupied by the present yard, and from that date to the present the growth has been a steady one, the present yard covering a little over 31 acres, and employing an army of 5,600 men, whose wages alone amount to $54,000 a week.

An excellent idea of this large establishment, and of some of the notable ships to which it has given birth, may be gathered from the accompanying bird's eye view. The buildings are mainly of brick, or of steel frames covered with corrugated iron. The most notable structure is a large building 1,164 feet long by 72 feet wide, and from two to three stories high, in which are included joiner and pattern shops, machine and erecting shops and two mould lofts. The iron foundry is 415 feet long by 264 feet wide, and the boiler shop—the largest of its kind in America—is 387 feet long by 112 feet wide, and it is furnished with two electric traveling cranes capable of handling 70 and 90 ton boilers with ease. There are five large building slips 600 feet long by 75 feet wide, and five wet docks from 600 to 1,000 feet in length, together with a dry dock 462 feet by 70 feet, with a sill depth of 22 feet. In the center of the picture, alongside of the armored cruiser New York, is seen the celebrated floating derrick, known as the Atlas, the largest of its kind in the world. It has a lift of 60 feet, and a radius of 35 feet, for a load of 125 tons.

The yard has a complete pneumatic, hydraulic and electric plant, and in addition to its ship and engine building facilities, it boasts of an ordnance plant for the manufacture of rapid-fire guns up to 4 inches caliber.

The total output of ships from this yard to date is nearly 300, and includes the Morning Light of the days of the clipper; the New Ironsides, an early broadside ironclad; the four fine ships Indiana, Illinois, Pennsylvania and Ohio, built for the American Steamship Company in 1872; and a veritable fleet of ships for the new navy, in which is included such famous creations as the armored cruisers New York and Brooklyn, the commerce destroyers Minneapolis and Columbia, and the battleships Indiana, Massachusetts and Iowa.

Last, and perhaps most brilliant achievement of all, was the construction of the two great transatlantic steamships, St. Louis and St. Paul, of 11,629 tons displacement, and 20 to 21 knots sustained sea speed. The advent of these twin ships to the transatlantic route may be taken as an earnest of the fact that the United States are determined to win back something of the old time prestige, which was hers when her clipper ships were the fleetest that crossed the seas.

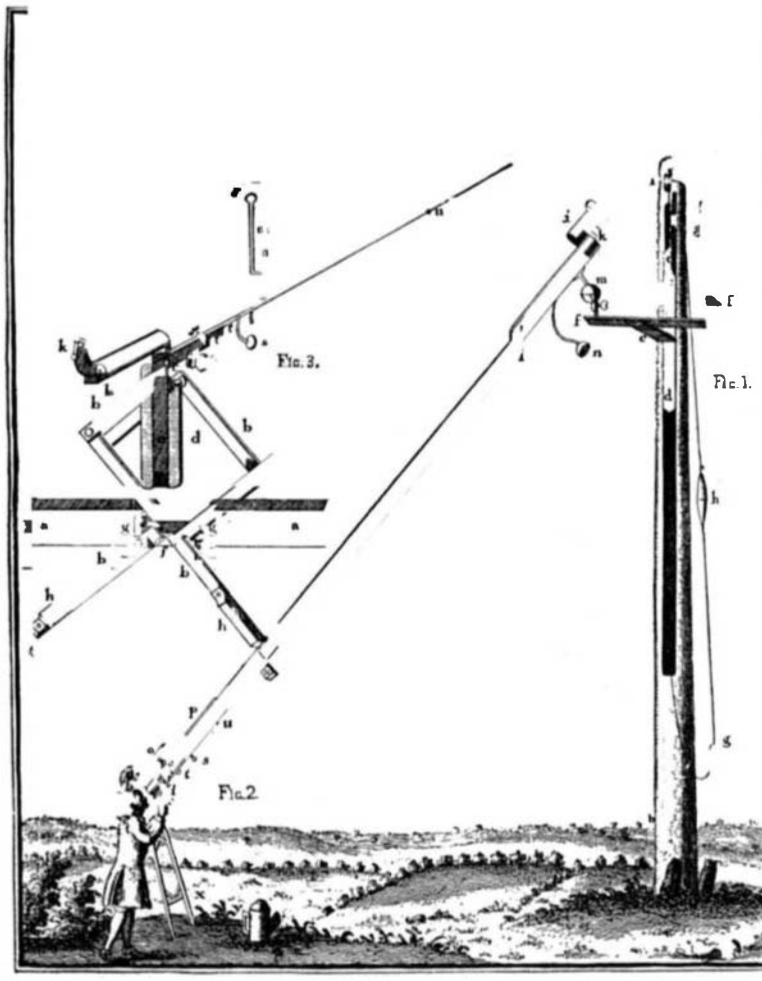
DEVELOPMENT OF THE ASTRONOMICAL TELESCOPE IN FIFTY YEARS.

Like almost every great invention dating back a century or more, it is very difficult to obtain data of a positive character regarding its early history. It will be useless in an article of this nature to speculate on the indirect evidence that may be gathered from the writings of Greek and Latin authors, but from such writers as Roger Bacon we are able to obtain information of a very satisfactory nature regarding the properties of lenses.

Mention is made of the use of lenses in "Pantometria," by Thomas Diggs, in the sixteenth century. Dee's preface to an edition of Euclid, published by him in 1570, has some remarkable passages on the use of lenses. Batista Porta, in a work published by him in 1561, describes a combination of concave and convex lenses. Henry Lippershey, about 1607, seems to have the best evidence on his side as the inventor of the telescope. In 1609 Harriot made observations on celestial phenomena with an instrument probably made in England, and Sir William Lower, a Welshman, asked Harriot to procure a cylinder (telescope) for him. Galileo, in the same year, learning that the telescope had been invented, made one. Afterward he made a larger one, with which the greatest astronomical discoveries ever recorded were made. Kepler improved the instrument by substituting a convex for a concave eye lens. Huygens made a telescope in 1655 having a focal length of 12 feet, with which he discovered Titan, Saturn's largest moon. His brother made telescopes 107 and 210 feet focal length. About the same time Campani, at Bologna, and Divini, at Rome, were making fine lenses of 90 to 130 feet focal length.

The reflecting telescope was invented by Gregory, in the middle of the seventeenth century. Newton invented his telescope in 1666, and in 1672 Cassegra improved the Gregorian telescope by making the secondary or small mirror with a convex surface, so as to intercept the rays from the great mirror before they came to a focus.

In 1732 James Short, a young Scotchman, made glass reflectors, silvered on the back; but he soon substituted speculum metal for glass. About forty years later Sir William Herschel commenced his wonderful career as an astronomical telescope maker, producing beautiful mirrors of speculum metal from 6 to 48 inches in diameter. Contemporaneously Schroeter, in Germany, made some excellent reflecting telescopes, and, like Herschel, made many interesting observations with instruments of his own construction.



HUYGENS' AERIAL TELESCOPE, 1655.

Having done thus much in the way of a hasty review of the early history of the telescope, we will state a little more in detail what has been done in the way of development of the astronomical telescope within the last fifty years.

From 1840 to 1845 Lord Rosse designed and constructed several large and powerful reflecting telescopes, one of which was six feet diameter and fifty-four feet focal length. The work of this telescope upon nebulæ and star clusters has become historic.

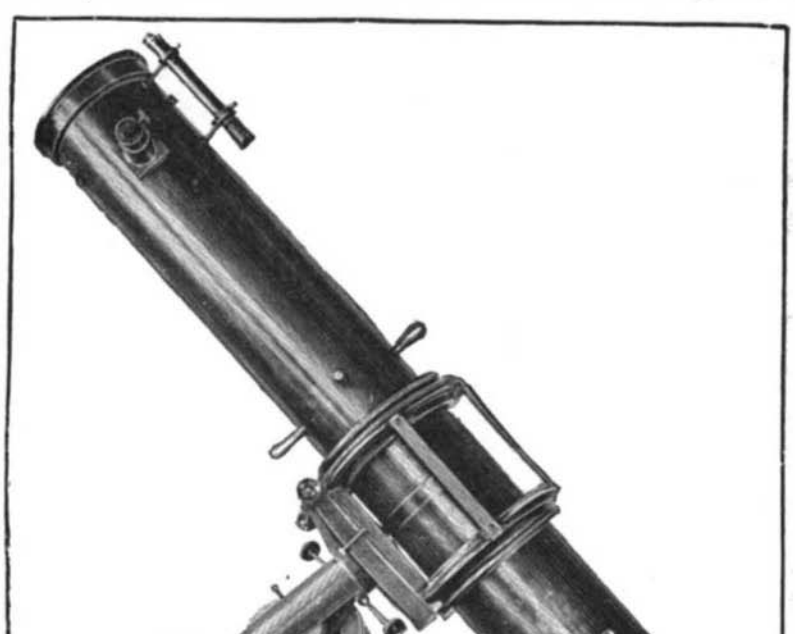
In 1861 Lassell erected his great reflecting telescope on the island of Malta, and Dr. De la Rue constructed several fine reflecting telescopes which he used in photographing the moon, etc.

In 1868 Mr. Thomas Grubb finished the great Melbourne reflecting telescope. For this telescope two 48 inch mirrors of speculum metal were furnished. In almost all reflecting telescopes used up to 1854 speculum metal was employed. This is composed of sixteen parts pure copper, fifty-eight parts pure tin, with slight modifications by various makers.

About the year 1850 Liebeg discovered a method of depositing pure silver on a glass surface. In 1856 Steinheil took advantage of this fact and was perhaps the first to make the now well known silver on glass specula, in which the silver is deposited on the first surface, which has been accurately polished and corrected before the silver is deposited upon it. A year later Leon Foucault described his method of making silver on glass mirrors, and made with his own hands many beautiful surfaces. By this method M. Eichens made the 48 inch mirror for the Paris Observatory, and a few years later Dr. Henry Draper made the 15 inch silver on glass telescope with which he obtained such beautiful results in lunar photography. Later on he constructed a silver on glass telescope of 28 inch aperture, by which he photographed the spectra of stars for the first time. These telescopes are now mounted at Harvard College Observatory. Dr. Draper published a most valuable monograph on the silvered glass telescope in 1864, and by its aid hundreds of amateurs have made very creditable reflecting telescopes.

But we must go back to the middle of last century to record what proved to be the greatest invention of the age in the way of developing the refracting telescope. Notwithstanding Newton's dictum that it was useless to try to improve it, owing to the impossibility of producing refraction without dispersion, Euler read a paper before the Berlin Academy in 1747 proving mathematically the possibility of correcting both the spherical and chromatic aberration of an object glass; and curious to say, the very man who published an adverse criticism of Euler's paper was no less a person than the celebrated John Dollond, who is recognized as the father of the achromatic telescope, for upon reading Klingenstierna's paper corroborating Euler's views, Dollond made a series of most valuable experiments which led him to the solution of the problem of the achromatic object glass; namely; that by properly combining two kinds of glass, flint and crown, he could unite the colored rays fairly well and still have refraction to unite the incident rays to form an image. Here we could fill a column with many interesting items of Dollond's work, but lack of space forbids. It is true that when Dollond applied for a patent to protect his discovery, it was claimed that Chester Hall had invented the achromatic objective as far back as 1829; but Lord Mansfield, who tried the case, remarked, "It was not the person who locked his invention in his scrutoire that ought to profit for such invention, but he who brought it forth for the benefit of the public."

Dollond's work soon became famous. He was surely master of it and had a clear field for many years, but he labored under great difficulties in procuring glass suitable for telescopes of any diameter. The writer has read an original letter from Dollond to Prof. Loomis, of Yale, in which he asked three years for the completion of a five inch telescope. Fortunately a genius had taken hold of this problem in the person of Guinand, a Swiss watchmaker, the story of whose life work is as charming as that of Palissy the Potter. After long experimenting, Guinand solved the problem of making fine disks of optical glass, and having associated himself with the celebrated Fraunhofer, in 1805 successfully made optical glass disks up to fifteen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