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THE YERKES OBSERVATORY.

America has now obtained a very gratifying position in the scientific world, not only by reason of the individual efforts of her scientific men, but also on account of the splendidly equipped institutions maintained by the government or through the munificence of private individuals. The poorest citizen can write to the proper bureau at Washington on any scientific question germane to that bureau or division which may puzzle him and he will receive a prompt and courteous reply, either dictated by or passed upon by some specialist of reputation. The value of our Smithsonian Institution is recognized all over the civilized world, and in astronomy it is gratifying to note that the astronomers of America have had their researches properly recognized abroad.

The United States is fortunate in possessing observatories equipped with the two greatest refracting telescopes in the world—the Lick and the Yerkes observatories, situated respectively at Mount Hamilton, Cal., and Williams Bay, Wis.

The Yerkes Observatory, of the University of Chicago, was founded in 1892 through the liberality of Mr. Charles T. Yerkes, prominent in railroad circles in Chicago. Williams Bay, near Lake Geneva, Wis., was selected as a good location for astronomical work. The contract for the 40 inch object glass, the largest in the world, was awarded to Mr. Alvan G. Clark, in 1892, and that for the equatorial mounting to Messrs. Warner & Swasey, of Cleveland, O., who made the mountings for the great telescopes at Washington, D. C., and Mount Hamilton, Cal. The mounting of the Yerkes telescope, though not entirely finished, was exhibited at the World's Columbian Exposition in 1893. It is similar to that of the Lick telescope, but is heavier and more rigid.

ERECTING THE DECLINATION AXIS OF THE YERKES TELESCOPE.

The optical glass for the objective was made by Mantois, of Paris, which is the only concern capable of turning out disks of the required size. The object glass required two years of unremitting labor to finish it. It has been examined by a committee of experts and it was found entirely satisfactory. The definition was found to be fully equal to that of the Lick telescope, and Prof. C. A. Young states that it gathers 23 per cent more light than the hitherto unrivaled objective in the Lick Observatory. The great glass will do honor to the sole survivor of the famous firm whose product is recognized even by foreign governments, for the Clarks furnished the 30 inch lens of the Pulkowa Observatory.

The crown glass lens of the great object glass is double convex, about 2½ inches thick in the middle, though only ¾ of an inch at the edge. It weighs 200 pounds. The flat surface of the plano-concave flint glass lens faces the eye of the observer.

This lens is about 2 inches thick at the edge and 1¼ inches in the center, and weighs over 300 pounds. The two lenses are separated by a space of 8⅜ inches, and are set upon aluminum bearings in a steel cell itself weighing 500 pounds; so that the whole mass which has to be carried at the upper end of the telescope tube amounts to nearly a thousand pounds.

The focal length of the object glass is 61 feet; so that the total

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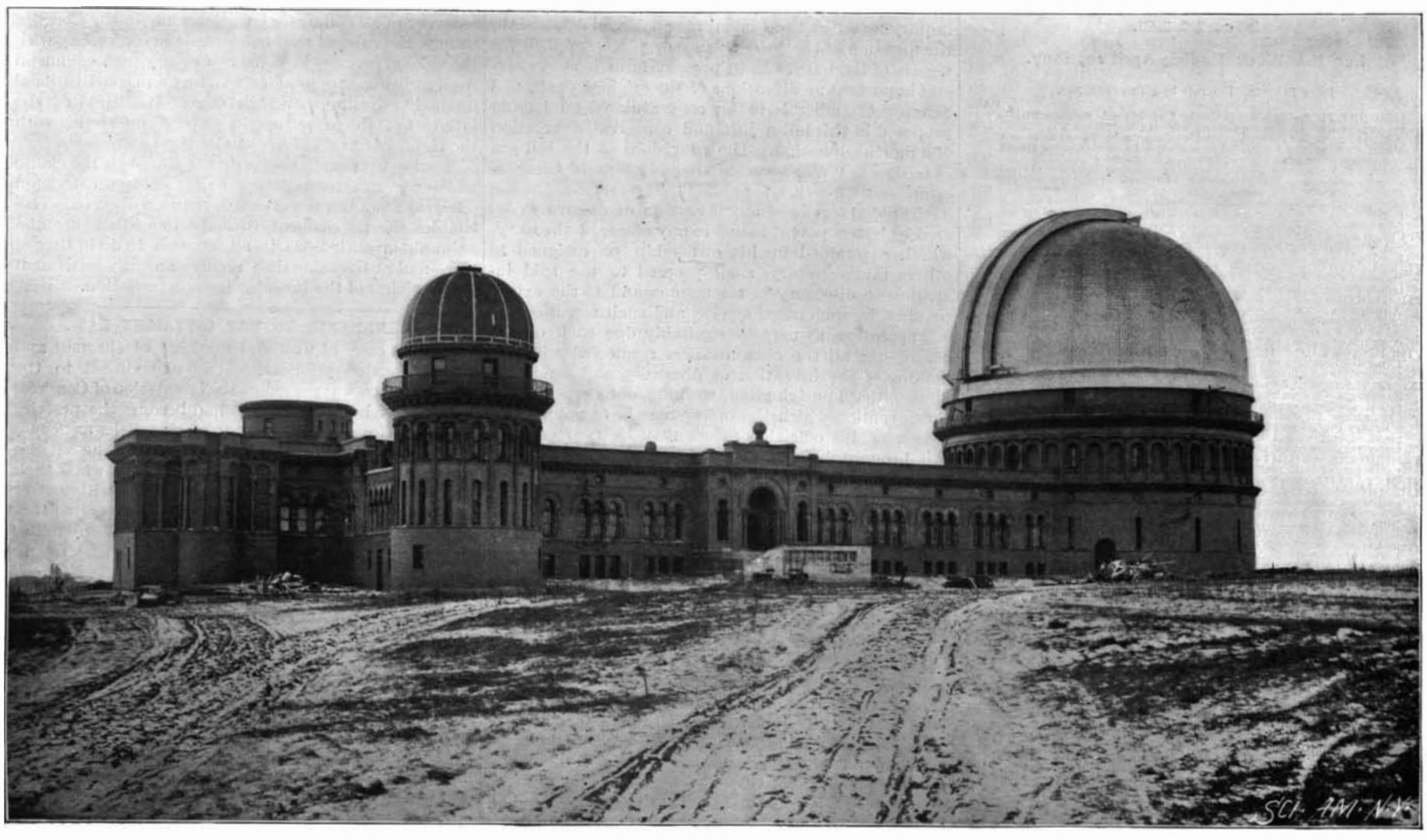


THE YERKES OBSERVATORY OF THE UNIVERSITY OF CHICAGO AT WILLIAMS BAY, WIS.

THE YERKES OBSERVATORY.

(Continued from first page.)

length of the instrument will be between 62 and 63 feet. This will be increased by several feet when the spectroscope is in place, and a dew cap about 7 feet long will project beyond the object glass. The image of the sun or moon formed in the focal plane will be nearly 7 inches in diameter.

The magnifying power of the telescope can be made by mere change of eyepiece to range of 200 to 4,000. The highest power will bring the moon, optically, to within about 60 miles of the astronomer's eye, but very much lower powers are used in practice, as more can be seen with them.

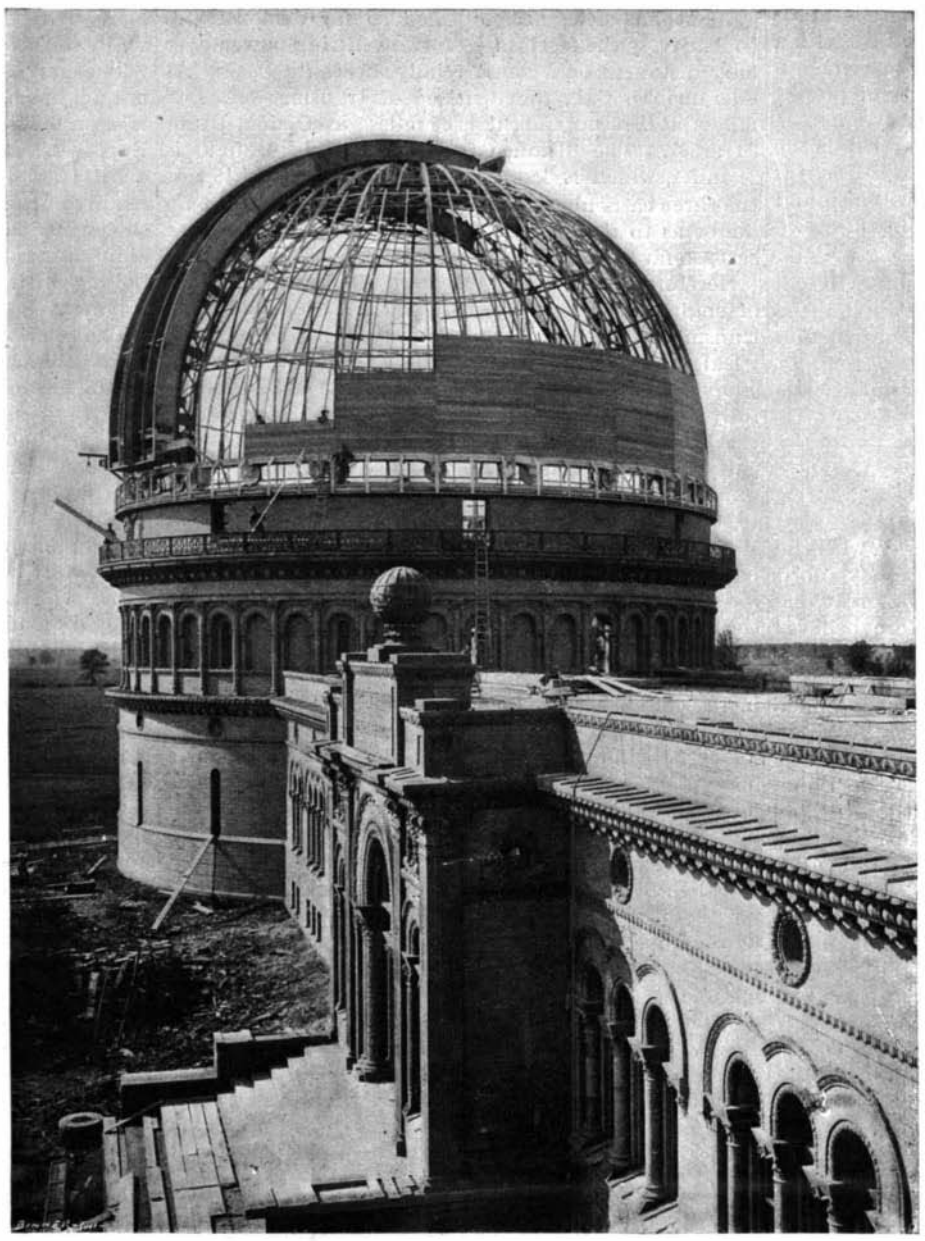
The Observatory building, of which we present (by courtesy of the Director) an engraving showing its present condition, is situated on the northern shore of Lake Geneva, about seventy-five miles to the northwest of Chicago, in an ideal rural region, free from the dust and smoke of cities and the tremors caused by traffic. It is one hundred and eighty feet above the water and stands in a tract of ground which was given especially for it. The site of the observatory includes about fifty acres of wooded land fronting on the lake. It is believed that the conditions will be favorable for the most delicate investigations in all branches of astronomy and astrophysics.*

The architect of the building was Henry Ives Cobb, whose Fisheries building at the Chicago Exposition attracted much attention. The building is in the form of a Roman cross, with three domes and a meridian room. The longer arm, running east and west, is about three hundred and thirty feet long. The great dome, in which is housed the big telescope, is situated at its western extremity and the meridian room is at the other end. The cross arm carries a smaller tower and dome at each end. The 12 inch telescope, which was formerly at the Kenwood Observatory, Chicago, has been set up in the northeast tower and has been in daily use. The other dome is not built as yet. In the southern dome a 16 inch telescope will eventually be placed. It is expected that a great deal of the minor work of the observatory can be conducted with these two instruments; for any work which can be done with a moderate sized instrument, can be accomplished much more readily and rapidly with a small telescope than with a large one, and Prof. Young aptly says that "an observatory equipped with one great telescope only is much like a warship with no rapid fire guns." Between the two small domes is the heliostat room, 104 feet long and 12 feet wide. A heliostat with 24 inch plane mirror will stand on a pier at the north end of the room under an iron roof which can be rolled away to the south.

The meridian room is designed to receive at some time a first-class meridian circle, but at present a small transit instrument is used. The room has double sheet iron walls with an intervening air space. The body of the building is divided through the center by a hallway extending from the meridian room to the tower which supports the great dome. On either side are offices, computing rooms, library, lecture room, two spectroscopic laboratories, photographic and chemical laboratories, galvanometer rooms, etc. In the basement is a dark room, an enlarging room, a concave grating room, with large concave grating spectroscope, constant temperature room, physical laboratory, optician's room, etc.

The instrument shop, which has been fitted up under the direction of Prof. Wadsworth, must be regarded as an extremely important adjunct in the observatory work. In this shop the various pieces of apparatus needed for the investigations of the observatory are constructed.

The optical laboratory is being fitted up by Mr. Ritchey, optician of the observatory. It might be reasonably supposed that this work was undertaken because of a lack of instrument makers, but this is not the case. American optical instrument makers are second to none. It is believed, however, that the best results can be obtained only when instruments of research are constructed under the immediate supervision of those who are to use them. Desirable changes in construction or design which become evident as the work progresses can, under these circumstances, be readily and inexpensively made, and it is believed that the instrument makers themselves will benefit by it in the end.



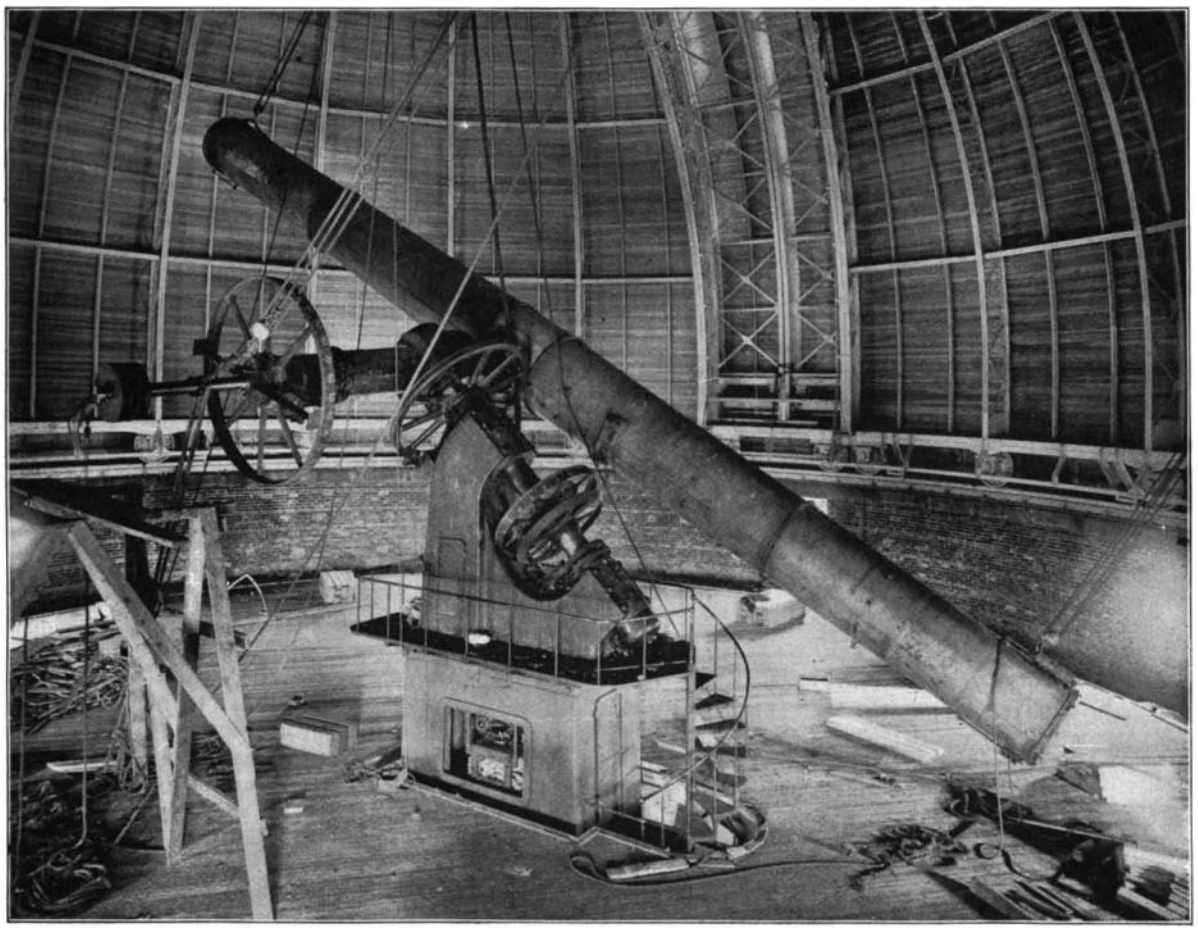
GREAT DOME OF YERKES OBSERVATORY, OCTOBER, 1896.

The power for working the motors of telescope dome, rising floor, and instrument shop, and electricity for lighting and steam for heating is all generated in a separate building at some little distance from the observatory proper, equipped by Mr. Yerkes with two 40-horse power Ideal engines, direct connected to Siemens-Halske dynamos.

The telescope stands under the great dome of the observatory. The column and head, which are of cast iron, rise to a height of 43 feet and weigh 50 tons. A spiral staircase at the south side of the column leads to the clock room, which is in the upper section, and to the balcony which surrounds the head. The polar axis is made of steel, 15 inches in diameter, 13½ feet long, and weighs 3½ tons. The declination axis is of steel, 12 inches in diameter, 11½ feet long, and weighs 1½ tons. The tube, also of steel, is 64 feet long and 52 inches in diameter at the center, tapering toward the ends. Its weight is 6 tons, but it is so beautifully balanced that a pressure of twenty pounds would move it easily.

The driving clock is controlled by a double conical pendulum, mounted isochronously, and is kept wound automatically by an electric motor, and weighs 1⅛ tons. It is geared to the main driving wheel, 8 feet in diameter, which, when clamped to the polar axis, revolves it, together with the tube and all its accessories, a weight of 20 tons, in exact sidereal time.

All quick and slow motions and clamps, both in right ascension and declination, are operated electrically and also by hand, the electric motors, magnets, and illuminations being controlled from a switchboard placed within easy reach of the astronomer. The assistant astronomer also has full control of the quick motions in right ascension and declination from the balcony. The old style hand attachments for the slow motions are not entirely done away with, but are provided solely as a measure of precaution in case of disabling of the electrical plant or the breaking of a wire, electric motors being coupled directly to the different slow motion screws. Little now remains to be done to the mounting. The dome and rising floor are also finished, and in a short time the large object glass will be in place and the telescope will be ready to use for actual observations.



MOUNTING OF THE 40-INCH YERKES TELESCOPE, SHOWING RISING FLOOR.

The attachments of the Yerkes telescopes will include: 1. A position micrometer by Warner & Swasey. 2. A solar spectrograph, for micrometrical and photographic investigations of the spectra of solar phenomena. 3. A spectro-heliograph, for photographing the solar chromosphere, prominences and faculæ by monochromatic light. 4. A stellar spectrograph, for researches on the spectra and motions of stars, nebulæ, comets and planets.

One of our smaller engravings, for which we are indebted to the Astrophysical Journal, shows the process of erecting the declination axis of the Yerkes telescope. Our other en-

* For a more detailed statement regarding the site of the observatory and the circumstances which influenced its selection see the Astrophysical Journal, March, 1897.

graving shows the mounting of the telescope; the photograph was taken in November, 1896, and the rising floor is shown at its highest level. Our third small engraving shows the skeleton steel construction used in the dome. The great dome with its elevating floors is among the unique features of the observatory. The elevating floor of the Naval Observatory at Washington was designed and constructed in 1892 in a similar way to that of the Yerkes Observatory, except that the floor is operated by hydraulic rams instead of electrically, as is the case with the new observatory.

The great dome of the Yerkes Observatory, 90 feet in diameter and 60 feet high, was designed and constructed by Messrs. Warner & Swasey. The dome consists of a framework of steel girders covered with a sheathing of wood and tinned on the outside only; it weighs 140 tons and revolves on thirty-six wheels running upon a circular track of T rails built upon the masonry walls. The journals for the wheels are provided with anti-friction bearings. The dome is revolved by means of an endless cable connected with the turning mechanism and operated by an electric motor.

The two shutters are 85 feet long, covering the opening, which extends from the horizon to a point 5 feet beyond the zenith. They are supported on tangential tracks at their extreme upper and lower ends, and run on wheels with anti-friction bearings. They are so easily adjusted that a direct pull of 72 lb. at the lower end moves the shutter its whole length, its position being maintained parallel with itself throughout the entire distance of motion by special mechanism. The shutters open from the center outward and work simultaneously.

The elevating floor, also designed and constructed by Messrs. Warner & Swasey, is 75 feet in diameter and weighs 37½ tons. The floor is circular in shape, and completely surrounds the telescope column, which is placed practically in its center. The floor is supported by four cables 90 degrees apart, and is carefully counterbalanced by weights running in four columns which serve as guides. The ropes for operating the floor also run in the same columns over sheaves placed at the top, the other end of each of the four ropes being wound around separate drums 4 feet in diameter, placed at the base of each of the columns. The drums are operated by worm gearing, and all four of the shafts which run the worms are operated from a single point by means of an electric motor, the arrangement of the drums and operating mechanism being such that the different positions of the elevating floor are always parallel to each other.

A balcony five feet wide surrounds the inside of the dome at the lowest position of the elevating floor, and another one 23 feet above it at its highest position, as shown in our engraving. When the telescope is directed to the zenith, the objective will be some seventy-five feet above the normal level of the floor.

The organization of the Yerkes Observatory is as follows: George E. Hale, director and astrophysicist; S. W. Burnham, astronomer; E. E. Barnard, astronomer; F. L. O. Wadsworth, astrophysicist; Ferdinand Ellerman, assistant; G. Willis Ritchey, optician.

When the great object glass is in position, it is certain that the observatory will become a place of pilgrimage for astronomers of all countries.

Sensationalism in science is greatly to be deplored, and it should be remembered that the instrument is but slightly larger than that of the Lick Observatory, and while it is certain that excellent work can be done with it in many departments of astronomy and astrophysics, it is not at all probable that discoveries of a sensational character will be made.

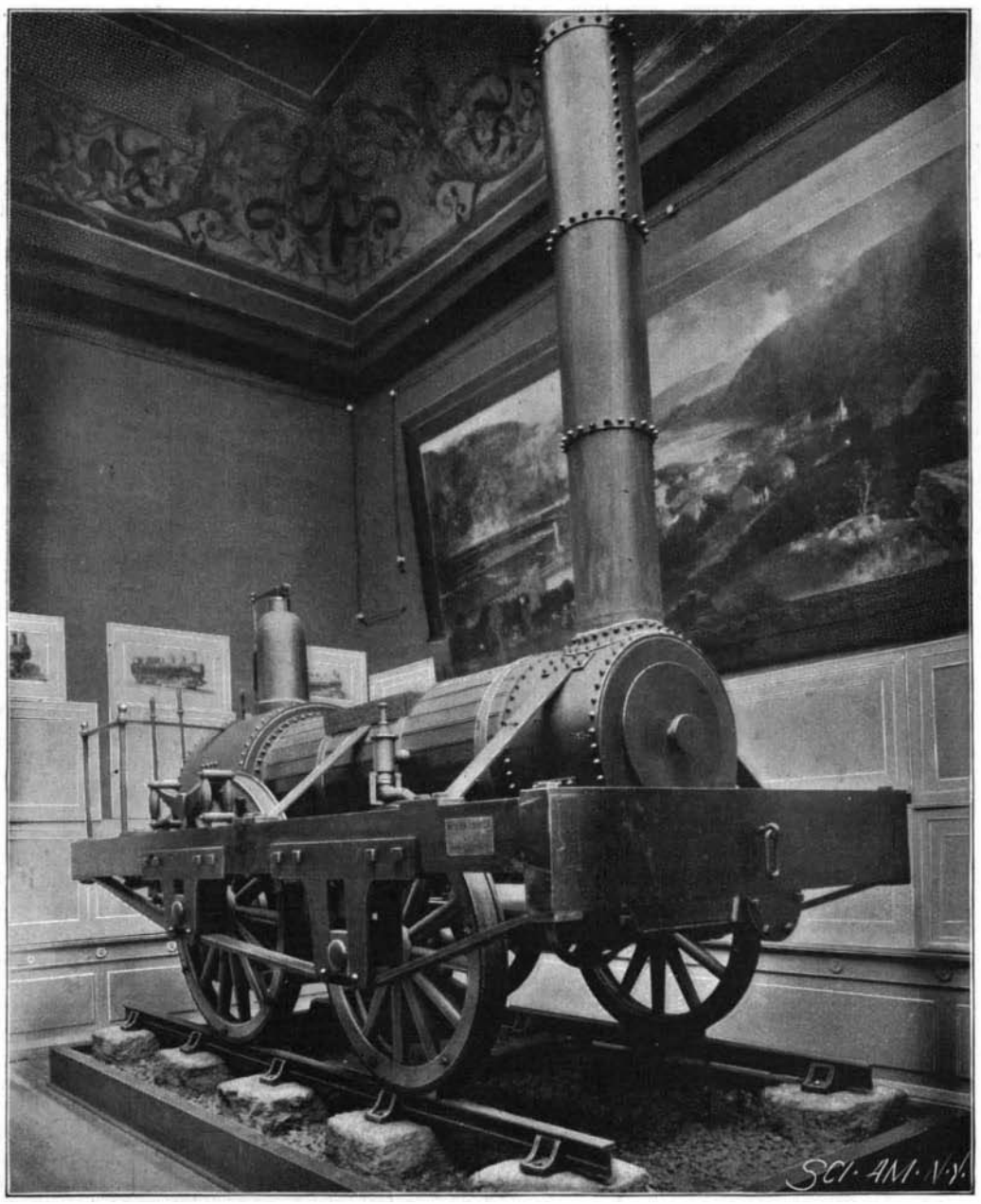


Fig. 1.—OLD IRONSIDES, BALDWIN'S FIRST LOCOMOTIVE—BUILT 1832.

THE FIELD COLUMBIAN MUSEUM, CHICAGO.

The great Columbian Exposition of 1893, at Chicago, has left an enduring record in the practical benefits which it has brought to the world in general and to this country in particular. It served to point out in one great object lesson the unrivaled growth of the United States in everything that goes to make up the sum of modern civilization, and it brought to our shores the best products of the skill and genius of other nations. It served as a great assembly hall for the wise and gifted of all the earth, and during the months of that memorable summer the choicest minds of the old and new worlds met in the friendly discussion of the great, burning questions of art, science, and religion. These are facts that were so fully and eloquently recognized and declared at the time that it is a mere repetition of a well known truth to insist upon them now.

But apart from—or rather over and above—the unseen but none the less potent benefits which the great event left in its train, there stands to-day, at the northern end of Jackson Park, a magnificent memorial of the exhibition, which is a concrete evidence of the beauty and magnificence of its buildings and the unrivaled excellence of the exhibits which they contained. We refer to the classic structure known during the exposition as the Fine Arts building, but now bearing the name of the Field Columbian Museum.

The auctioneer's hammer and the great conflagration at the close of the fair swept away from the broad area of Jackson Park practically every building of note, leaving, as was fitting, the most substantial and architecturally the most choice of them all to stand as a permanent and adequate memorial to the grandeur which once spread out before its noble facade.

There is an impression abroad that the creation of a permanent museum in connection with the exposition was an afterthought, begotten in the closing hours of "the Fair." This is quite incorrect. As a matter of fact, the idea first took shape in 1890, when it was suggested by Prof. Putnam, of Cambridge, Mass., in a letter to the Chicago Tribune. The idea was fostered during 1891 by Director Goode, of the National Museum, and by the members of the foreign affairs committee of the exposition directory. To this committee, of which President Baker was chairman, the excellence of many of the departments of the museum, especially the anthropological and transportation departments, is due; purchases being

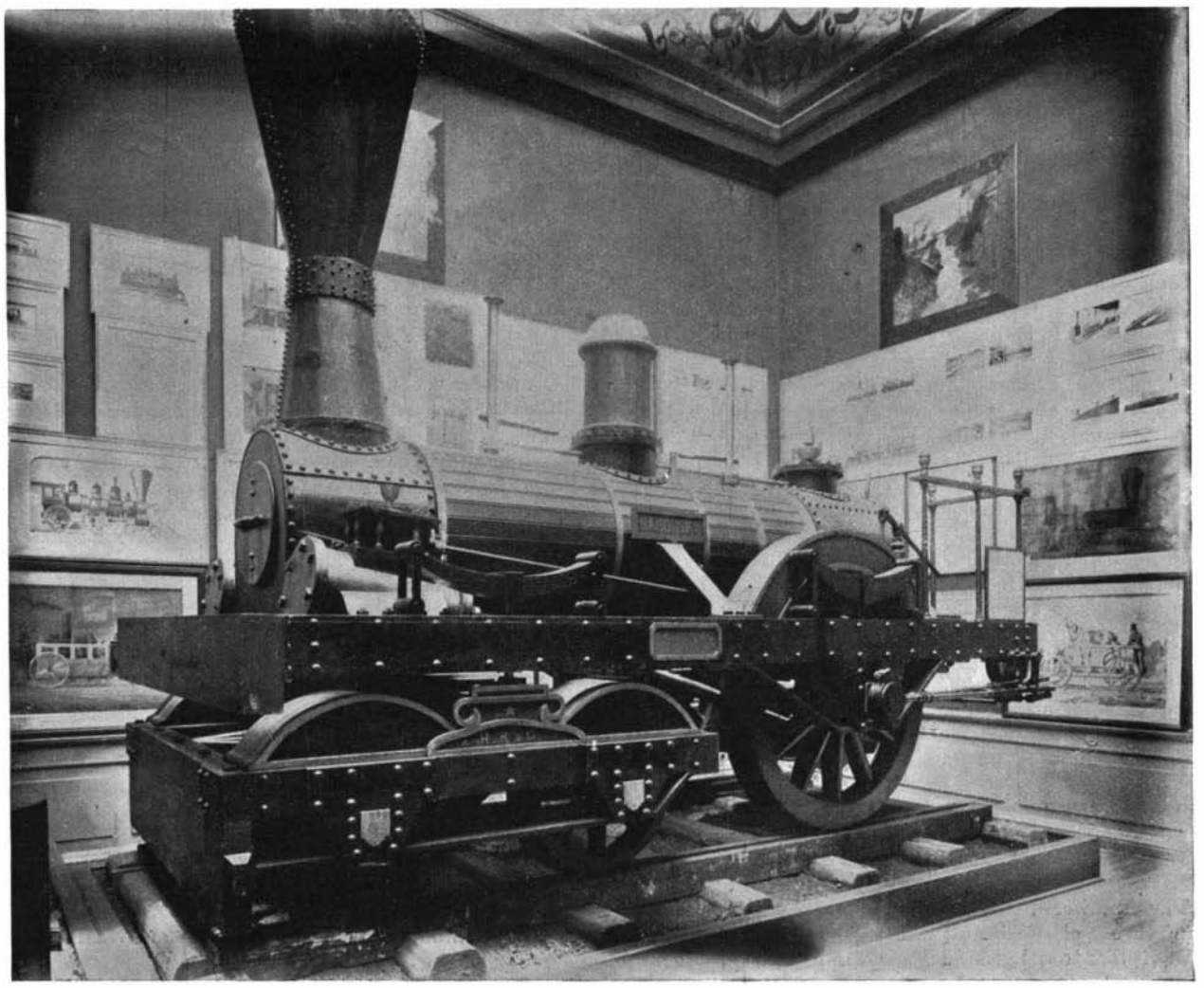


Fig. 2.—ROGERS LOCOMOTIVE SANDUSKY 1837—FIELD COLUMBIAN MUSEUM CHICAGO.