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THE DETROIT OBSERVATORY OF THE UNIVERSITY OF MICHIGAN.

ASAPH HALL, JR., PH.D.

This Observatory was built about 1854 through the efforts of President Tappan, money for the purpose being raised in Detroit. Mr. Henry N. Walker of Detroit was especially interested in the project and gave funds for the purchase of a meridian circle.

The Observatory building is of the usual old-fashioned type, a central part on the top of which is the dome for the equatorial, and east and west wings, the meridian circle being in the east wing and the library in the west. All the walls are of heavy masonry.

About 1853 Dr. Tappan visited Europe and consulted Encke, director of the Berlin Observatory and Professor of Astronomy in the University of Berlin, with regard to the Ann Arbor Observatory. By his advice a meridian circle was ordered of Pistor and Martins and a clock of Tiede.

At this time Francis Brünnow was first assistant in the Berlin Observatory. Probably it was through Encke that Brünnow came, in 1854, to the University of Michigan as the first Professor of Astronomy and

Director of the Observatory. I think it likely that the 12½ inch Fitz equatorial was ordered before his coming; but it was not delivered till after he was on the ground. The object glass first made by Fitz was rejected. The glass finally sent, said to be the best of the Fitz glasses, is a fair one. It defines well, but reflects considerable light from the interior surfaces.

The equatorial mounting was of the usual German form in vogue at that period, it being necessary to climb steps to read the circles and set them. The driving clock was too weak, and, as far as I can learn, has never been of any use. Also, there has always existed a good deal of trouble with the illumination of the wires. In its present condition the equatorial is of little use.

The meridian circle furnished by Pistor and Martins is of the high order of workmanship which these artists gave to every instrument which left their shop. However, in some respects I would criticise it. The telescope is not symmetrical in length with respect to the cube, rather a disadvantage, and causing considerable excess of flexure at the longer end. As with a number of Pistor and Martins' meridian circles, the microscopes are on the ends of arms, the arms being clamped to metal rings which are let into the stone piers and to which are attached the Y's which support the pivots. Although these arms seem to be quite steady, this method of construction has been generally abandoned, as there is danger that the arms may move.

The pivots are supported by large, rectangular shaped pieces of brass, into which the Y's are cut, and there is about fifty pounds' weight on the Y's. The instrument is very steady. I think it may be a good thing to have it rest in this way on large pieces of metal which can be firmfly secured, rather than on light, thin lips, as is usually the case. But it is not possible in the arrangement as we have it to place the Y's of the hanging level over the parts of the pivots which rest on the Y's of the instrument. However, Pistor and Martins probably had this fact in mind and took a great deal of pains with the pivots. I have made two careful examinations of them with a spherometer calliper. Each pivot seems round, and of the same diameter throughout, though the pivots differ from one another slightly in diameter. The object glass and eye end of the telescope cannot be interchanged.

When Dr. Brünnow came to the Detroit Observatory, he made it at once a working institution. Observations of new asteroids and comets were undertaken, and a number of the asteroids which had lately been discovered were assigned to this Observatory to be systematically followed. The reobservation of the Bradley stars were taken up. During the period 1858–1862, Brünnow published the Astronomical Notices, a journal designed especially to secure the regular publication of obser-

Francis Brünnow.

vations made at Ann Arbor. In 1859 tables of Victoria prepared by him were printed by the Board of Regents of the University.

Dr. Brünnow never learned English well, and probably was not very successful as a teacher of popular astronomy. But to the few advanced students who came under him his instruction was of the greatest value. He was a man of first rate ability, he had been a favorite pupil of Encke, pursuing his studies and having his first experience in Astronomy just after the great advances made by Gauss and Bessel. He had had that thorough, elaborate, German training, which has done so much to advance all branches of scholarship. Probably no other student in America ever received as good instruction in Astronomy as James Craig Watson, Brünnow's successor at Ann Arbor, received from Brünnow.

In 1859, Brünnow gave up his chair at Ann Arbor to go to the Dudley Observatory, Albany, but returned in 1860 and was re-elected to his former position. In 1863 he again resigned, and returned to Germany.

During Brünnow's stay in Albany, Watson took charge of the Ann Arbor Observatory as Professor of Astronomy, without the title of Director. On his return to Ann Arbor in 1860 Watson was transferred to the chair of Physics, but when Brünnow again resigned in 1863 he was elected Director of the Observatory and Professor of Astronomy.

Very soon after his election Watson began the preparation of a series of charts of stars lying near the ecliptic, probably with the idea of looking for asteroids. This very laborious undertaking seems to have occupied a great deal of his time for ten years. His first asteroid, Eurynome, was discovered in 1863. In all he found twenty-two of these bodies. The last, Clytæmnestra, was discovered in 1877, all these, except one discovered in China in 1874, were found with the Fitz equatorial of the Detroit Observatory.

Watson's work on asteroids and comets may have led him to the preparation of his Theoretical Astronomy, treating of the theory of the orbits of asteroids and comets, and of the theory of special perturbations. This is an excellent work, and has been of great usefulness to Astronomers. It appeared in 1868, when Watson was thirty years old.

For a period of five years, beginning with 1869, Watson was associated with Benjamin Pierce in work on the improvement of the lunar tables. The results of these researches have not been published. Professor Watson took part in the eclipse expeditions to Iowa in 1869 and to Sicily in 1870, and had charge of the Transit of Venus party to China in 1874. In the expedition to Sicily he was the only one to be successful of the party with which he was connected, having separated himself from the others, who had located at the foot of Mount Aetna, where the clouds formed every day about the time of the eclipse. His Transit o

Venus party in China was very fortunate, obtaining observations of all the contacts as well as a large number of photographs.

By Admiral Rodgers, Superintendent of the Naval Observatory, Watson was asked to take part in the observations of the Solar eclipse of 1878, with the understanding that he should devote himself to such investigations as he considered most important. Watson had already corresponded with Leverrier on the subject of an intra-Mercurial planet, which Leverrier had suggested as an explanation for the motion of the perihelion of Mercury shown by his investigations. Indeed, there is no doubt now, since Leverrier's work has been revised by Professor Newcomb, that the motion of the perihelion of Mercury's orbit is a reality, whatever may be the reason of it. Watson became strongly convinced that an intra-Mercurial planet really existed and determined to look for it during the 1878 eclipse. During this eclipse, he discovered as he supposed two such planets. There was considerable dispute in the Astronomical Journals as to this discovery, the general opinion being that a mistake had been made by reason of the rude circles employed, and that the supposed planets were two known stars. However, Watson never lost faith in the existence of these planets. At the Washburn Observatory, Madison, whither he went as Director in 1879, he spent considerable money of his own in constructing an underground observatory for observing the sun and the region near it. Before this observing cellar was finished, Professor Watson caught a severe cold in it, bringing on a congestive chill from which he died.

Watson was a pleasant, easy speaker, and an interesting lecturer, so that the short course in general Astronomy which, during his term as Professor, was required of almost all students, was very popular. Watson gave, too, a short course of lectures to Engineering students on subjects which they would require in their work. Also, there was an advanced course in Astronomy, extending over two years, it being intended that students should begin it in their Senior year and remain one year after graduation.

This advanced course, wholly, or in part, was taken by a number of good students. They were attracted by Watson's reputation and abilities, by his love for teaching those who really cared for the subject, and by his wide knowledge. For sometime, too, advanced instruction in astronomy could hardly be obtained anywhere else. Also, Professor Watson was engaged in investigations for the Coast Survey and Nautical Almanac Office, the expenses of which were paid for by those institutions, so that he was able to furnish employment to a number of students of small means, and keep them at the observatory.

At this time the Government Surveys, too, called for men in field astronomy. A number of students went into this work. Toward the end of Professor Watson's term at Ann Arbor money was obtained for

James C. Watson

a students' observatory, in order that practical instruction might be given to those who were not necessarily going to make a specialty of Astronomy. This small observatory was not finished till after Professor Watson's departure.

In the fall of 1879, Mark W. Harrington succeeded Watson as Professor of Astronomy and Director of the Observatory. Under Professor Harrington the students' observatory planned by Watson was built, and the more extended course of instruction in practical Astronomy, as it is now carried on, was begun. Professor Harrington did some work with the equatorial and meridian circle, but his researches were mostly in the direction of meteorology. In 1884 he founded the *American Meteorological Journal*, the first seven volumes of which he edited. Through his efforts the Observatory was provided with improved meteorological instruments. He made extensive investigations with regard to the climatic conditions of Michigan, and, indeed, of our whole country. Also, during Harrington's term as Professor, 1879-1891, Schaeberle, instructor in Astronomy, made many observations with the meridian circle of stars for the Coast Survey and of Struve's double stars, and observed comets with the large equatorial and the small equatorial of the students' observatory. Campbell, who succeeded Schaeberle as instructor, made many comet observations and computed ephemerides.

When Professor Harrington went to Washington in 1891 as Chief of the Weather Bureau, Mr. W. J. Hussey was appointed instructor in Astronomy and afterwards Acting Director of the Observatory. Mr. Hussey made some observations of comets and computed ephemerides. He was succeeded in 1892 by myself as Professor of Astronomy and Director.

It may be proper to say a few words as to the present condition of the Observatory. The Regents lately granted money for the purchase of a clock, chronograph, and new micrometer for the meridian circle, but otherwise the equipment for research work is exactly the same as when the observatory was built, forty years ago, while astronomical instruments have been very much improved, and spectroscopy and astronomical photography have been developed since then. The meridian circle is a fair one yet, and I have undertaken with it the determination of a long list of latitude stars, making the places differential with respect to the *Berliner Jahrbuch* stars. The large equatorial is in poor shape. We ought to have a new instrument of about the same size with a first class glass and mounting, and an extra lens, so that it could be used for photography. The students' observatory should have a good theodolite for purposes of instruction in field astronomy. But more than anything else the Observatory needs an endowment so as to make it more of a working scientific institution, and secure the immediate reduction of observations.

FRANZ FRIEDRICH ERNST BRÜNNOW.

Franz Friedrich Ernst Brünnow was born in Berlin, in 1821, being the son of Johann Brünnow, a Privy Councillor of State. From 1829 to 1839 he attended the Friedrich-Wilhelm Gymnasium, and then entered the University of Berlin, from which he received the Doctor's degree in 1843, his thesis being entitled "De Attractione Moleculari." At the University he attended the lectures of Encke in Astronomy and of Dirksen, Lejeune-Dirichlet, Ohm, and Steiner in Mathematics and of Dove in Physics. After leaving the University Brünnow took an active part, under the direction of Encke, in the work of the Berlin Observatory, contributing numerous papers to the *Astronomische Nachrichten* In 1847 he was made director of the small Observatory at Bilk, near Düsseldorf. Here his work was the observation of asteriods and comets. At this place he wrote the memoir on De Vico's comet for which he received the gold medal from the Amsterdam Academy of Sciences.

During this time also, he prepared his *Lehrbuch der Spharischen Astronomie*, probably the best treatise we have on the subject. It has reached four editions, and has been translated into English, French, Italian, Spanish, and Russian. The first edition appeared in 1851, with a preface by Encke.

In 1851 Brünnow was called to Berlin as first assistant in the Observatory, to succeed Galle. He remained at Berlin till 1854. During this period his tables of Flora were published. In 1854 he came to Ann Arbor. Brünnow's work in this country has been spoken of under the foregoing notice of the Detroit Observatory. In 1863 he returned to Europe. In 1865 he was made Professor of Astronomy in the University of Dublin and Astronomer Royal for Ireland, to succeed Sir William Rowan Hamilton at the Dunsink Observatory. Hamilton's researches had been theoretical, so that it fell to Brünnow to reorganize the Dunsink Observatory, and start it again in the direction of observation.

He obtained an equatorial mounting for the objective which had been presented by Sir James South, and began active observations with this instrument. These observations are published in the *Astronomical Observations* and *Researches made at Dunsink*. They are models of accuracy and elegance, the determinations of stellar parallax being especially well known. In 1874 Brünnow's eye-sight began to fail and he resigned his position at Dunsink, going first to Basle, then to Vevey, and finally to Heidelburg. He was no longer able to engage to any extent in scientific work, but as he was very fond of music, gave most of his time to it. He died in 1891, in Heidelburg. In 1857 Brünnow married Rebecca Lloyd Tappan, daughter of Reverend Henry Philip Tappan. Their only son, Rudolf Ernst, is a student of Oriental Languages.

Mark W. Harrington.

JAMES CRAIG WATSON.

James Craig Watson was born in Fingal, County of Elgin, Canada West, in 1838, being the son of William Watson, farmer, and Rebecca Bacon. William Watson had some education and a taste for learning, but was easy going and shiftless. His wife was a woman of great energy and natural ability. They did poorly on their farm in Canada and when James was twelve years old, moved to Michigan, and finally settled in Ann Arbor, probably with the idea that they sometime might be able to send their children to the State University. In Ann Arbor the father found work in a factory, and James had employment about the samo place. When he was fifteen James entered the State University. He had had but little opportunity for instruction but had already shown extraordinary powers as a scholar in both mathematics and languages. Also, he was possessed of good mechanical ability, and, boy as he was, had run the engine in the factory where he was employed.

In the University young Watson was an excellent scholar in all directions. Brünnow recognized his great ability and promise and helped him very much. Probably it was through him that Watson went into Astronomy. In his Junior year Watson began work in the Observatory. Before graduating he ground a four inch objective and mounted it. In 1857 he was graduated and very soon was employed as an assistant in the Observatory. Gould's Astronomical Journal contains an article by Watson dated April 20, 1857, and from that time on we find many papers by him in the *Astronomical Journal*, the *Astronomical Notices*, the *American Journal of Science*, and the *Astronomische Nachrichten*. Many of the communications contained observations of comets and minor planets, with computations of orbits and special perturbations.

Watson was made Professor of Astronomy in the University of Michigan when Brünnow went to Albany, was transferred to Physics when he returned in 1860, and when Brünnow again resigned in 1863, was elected Professor of Astronomy and Director of the Observatory. The Ann Arbor position he retained till he went to the Washburn Observatory, Madison, as Director, in 1879. He died at Madison in 1880. Professor Watson married in 1860 Annette Waite of Dexter, Michigan. They had no children.

Watson was engaged in a number of business enterprises and acquired some means, a large part of which was left to the National Academy of Sciences for the preparation of tables of the asteriods found by him and for other astronomical investigations. He had considerable influence over business men, and this influence was used for very great good in modifying the insurance laws that were being framed for this State.

MARK WALROD HARRINGTON.

Mark Walrod Harrington was born in 1848 at Sycamore, Illinois, his father being of old New England stock, and his mother belonging to the New York Walradt family, originally from Holland. He was educated at Evanston and at Ann Arbor, graduating as A.B. from the University of Michigan in 1868. Soon after graduation he entered the Museum of the University as Assistant Curator. In 1870 he was made instructor in French and Mathematics, besides attending to his duties in the Museum. In 1871 he went to Alaska as Astronomical Aid in the U. S. Coast Survey reconnaissance, conducted by W. H. Dall. He returned to the University of Michigan in 1872, and was made instructor in Geology, Zoology and Botany. The next year he was appointed Assistant Professor of the same subjects. In 1876 he was granted leave of absence for two years and went to Leipzig to study.

In 1877 he was appointed Professor of Astronomy and Mathematics in the Cadet School of the Chinese Foreign Office. In 1879 he was made Professor of Astronomy and Director of the Observatory at Ann Arbor, succeeding Watson. In 1891 he was made Chief of the Weather Bureau, after Congress had resolved to place it under a scientific head.

Professor Harrington has travelled extensively and his studies have taken a wide range, embracing Botany, Astronomy, Mathematics, Geography and Meteorology. He is an honorary member of many learned bodies, and was President of the World's Congress of Meteorologists at Chicago in 1893.

JOHN MARTIN SCHAEBERLE.

John Martin Schaeberle was born in Germany in 1853, and with his parents, came to Ann Arbor in 1854. When he was fifteen he went to Chicago and served a three years apprenticeship in a machine shop, receiving a thorough training in the trade. While in Chicago he became interested in Astronomy, and studied what books he could obtain on that subject. Returning then to Ann Arbor he entered the High School to fit himself for the University of Michigan. During his High School course he made a small telescope. Entering the University in 1872 Schaeberle was graduated in 1876 as C.E.

Immediately after graduating he became Professor Watson's private

J. M. Schueberle.

assistant, being employed chiefly to compute for the *Berliner Jahrbuch* ephemerides and perturbations of the Watson asteroids. In 1878 he was appointed by the Regents Assistant in the Observatory. About 1878 Schaeberle began with the Ann Arbor meridian circle observations of a list of stars for the U. S. Coast Survey. Later the Struve double stars were taken up. Besides the meridian circle work he made many comet observations, and computed comet ephemerides. Also, he discovered two new comets, one with a telescope which he had made himself just after graduating from the University. During the twelve years of his connection with the Ann Arbor Observatory he gave instruction in the University and conducted much of the work in practical Astronomy.

In 1888 Schaeberle went to the Lick Observatory as Astronomer. His work there has been of a rather varied character. For some time he observed with the Repsold meridian circle. He took part in the eclipse expeditions sent out by the Lick Observatory in 1889 and 1893 to Northern California, Cayenne and Chile, and in this connection obtained results with regard to the Sun's corona which may lead to important discoveries. He made drawings of Mars during the oppositions of 1892 and 1894, and has made photographic investigations, publishing a paper on "Terrestial Absorption of Photographic Rays." He has communicated many papers to Astronomical Journals, some of them containing very ingenious methods for determining instrumental constants.

WILLIAM WALLACE CAMPBELL.

William Wallace Campbell was born in Hancock Co., Ohio, in 1862. He lived on a farm till he was fourteen. He entered the University of Michigan in 1882 and was graduated in 1886 as B.S. (C.E.) His principal work was with Professors Greene and Beman, and Mr. Schaeberle. From 1886–88 he was Professor of Mathematics in the State University of Colorado. From 1888–91 he was instructor in Astronomy in the University of Michigan. His principal work at the University of Michigan was teaching, but he also observed many comets and computed ephemerides.

In 1891 Mr. Campbell went to the Lick Observatory as Astronomer, having charge of spectroscopic observations. His principal work has been on *Nova Aurigae*, *Nebulæ*, *Wolf-Raget Stars*, various bright line stars, comets and *Mars*.

Mr. Campbell has contributed many articles to the *Astronomical Journal* and the *Astronomische Nachrichten*, and is known throughout the world as an original investigator in the new astronomy.

His late observations on the atmosphere of Mars, which go to show that Mars has not more than one-fourth as much atmosphere as the earth, have attracted much attention.

Mr. Campbell married, December, 1892, Elizabeth Ballard Thompson of Grand Rapids, Michigan.

THE IMPULSE WHEEL AS A STEAM TURBINE.

FRANK C. WAGNER, A. M., B. S.

It is intended in what follows to discuss from a theoretical standpoint the possibilities of the use of the impulse wheel as a steam engine and to compare the results obtained with what has already been accomplished in the use of steam turbines of this type.

In the impulse wheel used as a water motor the pressure acts to give the water a high velocity, the potential energy due to the pressure, or head, being converted into the kinetic energy of the moving water. The kinetic energy is then transmitted to the buckets or paddles of the wheel. Knowing the pressure or available head, it is an easy matter to calculate the velocity which the water will acquire. The maximum possible efficiency of the wheel is found by the use of Rankine's formula:

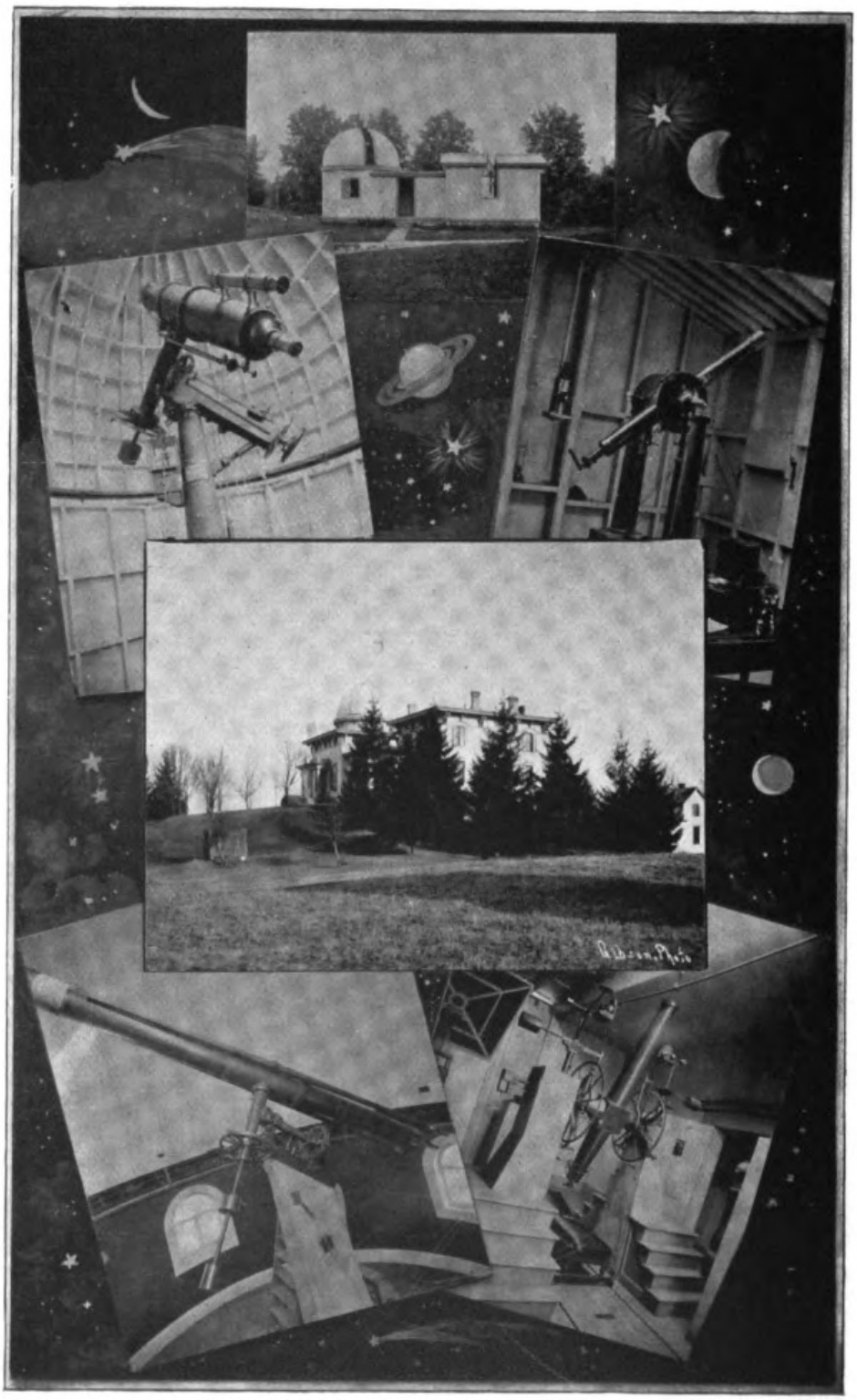
Efficiency $= 1 - k = \frac{4u(v_1 \cos\alpha - u)}{v_1^2}$ where u is the velocity of the buckets, v_1 the velocity of the jet of water as it strikes the vane, and α is the angle which the direction of motion of the bucket makes with the jet.

De Laval's steam turbine, which attracted so much attention at the Columbian Exposition, is a good example of the impulse wheel used as a steam turbine. The makers publish a test, made upon a 50 horse-power machine by Prof. Cederblom, in which the following results were obtained.

The steam pressure was 8.6 kilograms per square centimeter, equal to 122.3 pounds per square inch above the atmosphere, or 137 pounds per square inch, absolute. The back pressure was 0.12 kilograms per square centimeter, or 1.7 pounds per square inch, absolute. The brake horse-power was 63.7. The total feed water for an eight hour run was 4561 kilograms or 10,055 pounds. Hence the steam consumption per brake horse-power per hour was 19.7 pounds.

The maximum possible efficiency of any heat engine working under the above conditions is given by the second Law of Thermodynamics as follows: The temperature of saturated steam at 137 pounds absolute pressure is 351 degrees Fahr., or 812 degrees absolute. The temperature

W. W. Campbell



EXTERIOR AND INTERIOR VIEWS OF DETROIT OBSERVATORY.